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THE NEW AERODROME designed by Prof. S. P. Langley, of Smithsonian Institute, was given a test flight on Aug. 8 from a house boat on the Potomac River, near Wide Water, Va. According to the newspaper reports the aerodrome started well in a straight line with a velocity of 70 ft. per second, and flew for a distance variously estimated at from 1,200 ft. to 1,800 ft.; it then deflected downward and plunged into the river waters, from which it was recovered by means of grappling irons. The following report of the test was issued by Prof. Langley's chief assistants:

The experiment was entirely successful. All the data which this machine was designed to furnish were obtained. The equilibrium was perfect, the power adequate and the supporting surface ample. No accident occurred. Some of the woodwork of the wings and rudder was slightly damaged by the grappling hooks used in removing the aerodrome from the water, but no essential parts were injured.

THE FREE PUBLIC BATHS along the river front in New York are regarded as dangerous to public health by Dr. Lederle, President of the Department of Health. In the first place, some of them have been located at points where the water is polluted by sewage, but these have been shifted. The greatest danger lies in the spread of infectious diseases among the thousands of persons who use them. The Department is in favor of abandoning the river baths and substituting free public baths in the crowded sections of the city, where hot and cold fresh water would be provided for plunge and shower baths.

A PUBLIC PARK on Telegraph Hill, at San Francisco, is to be established, and will preserve this landmark from eventual destruction by the quarrying which is now carried on. Certain property will be acquired by the city to stop this quarrying, but a certain portion will be allowed to be removed for use in constructing the sea wall for the new harbor work. The park will be on the eastern slope, with boulevards and walks reaching the summit. At some future time a tunnel may be driven through the base of the hill to connect important streets. The plans for this improvement work have been made by the City Engineer.

THE REMOVAL OF THE BOSTON GARBAGE REduction plant from the Calf Pasture, on the mainland, to Spectacle Island, in the harbor, has been delayed, owing to a controversy over the extension of the city water supply to the island. The New England Sanitary Product Co., which owns and operates the reduction works, claims that the city is under obligations to bring the water to Spectacle Island. This the city denies, and it is said that there is no written agreement to that effect. The company has erected large buildings on the island, but has not moved its apparatus to them. Meanwhile the garbage is being treated at the old works. The city has paid the company $90,000 of the $140,000 agreed upon as the consideration for moving the works.

TYPHOID FEVER OUTBREAKS DUE TO OYSTERS subject to sewage discharges continue to be recorded. A recent British Parliamentary paper contains a report by Dr. Timothy Bulstrode, a local government inspector, on two such outbreaks. In each case, oysters from the same source were served at mayoral banquets, on the same day, in towns some distance apart. After an interval some of the honorable mayors in each group came down with typhoid, but those who did not eat the oysters escaped. The oysters were obtained from Emsworth, from beds only a few yards away from the outlet of the main sewer.

GAS ENGINES DRIVING DYNAMOS at the generating station of the electric railway running to Mount Vesuvius are arranged to be started by running the dynamos as motors. The dynamos are shunt machines for 500 volts normal pressure, and in parallel with them across the busbars is a storage battery of 300 cells. No boosters are employed, but the charging or discharging of the battery is regulated by raising the voltage of the generators by means of regulating rheostats in the field circuit. Reverse-current circuit breakers prevent the battery sending current into the dynamos except when a by-pass switch is opened for starting the machines from the battery. The dynamos are each belted to a gas engine of about 100 HP. To start an engine, the reverse-current circuit-breaker of its dynamo is opened and the by-pass switch closed, the field resistance being all cut out. The dynamo then takes current from the battery and starts up its gas engine. The maximum current taken in starting is about 60 amperes, which decreases as the set speeds up. The normal capacity of each dynamo is about 130 amperes.

THE REVIVAL OF AMERICAN SHIPPING in the foreign trade has been made a subject for agitation and investigation by the New York Board of Trade and Transportation. The board has adopted resolutions substantially as follows:

Our deep-sea tonnage has shrunk to one-third of the total of 1861, while most of our ocean commerce, which used to employ scores of shipyards and thousands of skilled mechanics and seamen, is now monopolized by other nations.

The American people must have prosperous shipyards and a great merchant fleet as a bulwark of their trade and the indispensable reserve of their fighting navy. Ship building and navigation, bringing a fair gain to capital and labor, are as vital to the nation's defense as armor-clads and guns.

Resolved, That a committee of five members, including the President of the New York Board of Trade and Transportation, be appointed by the President to inquire into the alarmingly depleted state of American shipping in the foreign trade; that this committee be urged to lay the subject before commercial associations, labor associations, and all interests concerned in the increase of our deep-sea tonnage; that the press of the country be invited to help in ascertaining and recording public opinion as to the best means by which our shipping may be built up; that all sides of the question be discussed thoroughly and without regard to political or economic bias, and that the committee report its conclusions to the Board no later than Dec. 1, 1903.

The chairman of the committee appointed in accordance with the above resolution is Mr. Aaron Vanderbilt, who may be addressed for further information at 203 Broadway, New York city.

A DYNAMITE MAGAZINE EXPLODED Aug. 9, at Akron, N. Y. Lightning is said to have struck the magazine, exploding two tons of dynamite stored therein.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a rear collision which occurred on the Grand Trunk Ry. at Durand, Mich., on Aug. 7. Twenty-three persons were killed in the resulting wreck, and many others were injured. A circus train was traveling in two sections, and the first of these had stopped in the yard at Durand, sending back a flagman and displaying a red tail light. The second section came on in spite of these warnings and ran into the rear of the standing train. The great loss of life was due to the fact that the last three cars of the first section were filled with sleeping circus men. The engineer of the second section claims that the airbrakes did not work, but this is denied by the superintendent of the road, who claims that the brakes were in order, but were not applied.

AN APPALLING ELECTRIC RAILWAY ACCIDENT took place on the Chemin de Fer Metropolitain, of Paris, France, on Aug. 10. A train running through a subway portion of the line took fire from a defect in the electric wiring and burned up completely, as did also two following trains. The fire occurred between stations, and the passengers trying to reach the stations in order to get out of the subway were suffocated or burned to death; or, in some cases, killed by the current from the third-rail. As far as can be learned up to the present, the list of the dead may exceed one hundred. The accident occurred on the North circle or northern half of the belt-line; this is the second section of the Metropolitain to be opened for traffic and has been in operation for only a few months. The North circle is nearly wholly in subway. The accident occurred near its eastern terminus, between the stations Les Couronnes and Menilmontant. The facts of the accident are not yet clear. It appears that an east-bound train reaching Les Couronnes was noticed to be smoking in the motors or other portion of the electrical equipment, and a following train was ordered to push it ahead to the terminus. Before the trains had gone more than a few hundred yards toward Menilmontant, the next station, the fire became so bad that it was decided to stop. One or two other trains also became involved in the fire. The passengers attempted to make their way to Les Couronnes or to Menilmontant, but most of them were overcome on the way. The heat destroyed the lighting wires so that the tunnel was in darkness, and a double bend in the line between the two stations made escape in the smoke and darkness difficult. The presence of the third-rails of the two tracks added to the confusion and danger. The fire was so fierce that no one could enter the tunnel, and many were killed even on the station platform of Les Couronnes. Rescue work could be begun only after many hours. We may note here that the trains used on the Paris Metropolitain are made up of motor and trailer cars with multiple-unit control. The cars are all single-truck, with full steel underframing. Each motor car is equipped with two 100-HP. motors.

THE DETERIORATION OF GAS MANTLES while burning was made the subject of a lengthy paper last winter, before the Michigan Gas Association. The paper was withheld from publication, awaiting further experiments. It was prepared by Mr. Alfred H. White, Director of Chemical Technology, University of Michigan, and Mr. M. E. Mueller. The paper was given in full in the "American Gas Light Journal" for Aug. 3, 1903, from which the following conclusions have been taken:

Our study of the subject of the deterioration of mantles while burning leads us to the following conclusions: The physical changes which take place in well made mantles are relatively unimportant. The greatest cause of the gradual deterioration is the loss of cerium oxide, which slowly volatilizes in the intense heat. Experiments on mantles containing originally more than 1% of cerium indicate that their efficiency increases until the cerium content of the hot zone has dropped to about 1%, and that from that point on they deteriorate. The rate of deterioration of commercial mantles varies greatly, but the important factor is still the decrease in the percentage of cerium. Some mantle manufacturers are able to very greatly lessen the rate of loss of cerium and thus make mantles which retain their efficiency for long periods. Our experiments do not support the theory of periodic change in the mantle's illumination, but confirm the position previously taken that the alteration of the heating power of the gas, with its consequent effect on the temperature of the mantle, is the most important factor in causing the fluctuations in the illuminating power of a mantle from one day to the next. The amount of moisture in the atmosphere also exercises an appreciable influence.

THE VICTORIA BRIDGE over the Brisbane River at Brisbane, Australia, is described in a paper read before the Institution of Civil Engineers of Great Britain by Mr. Alfred B. Brady, the chief engineer of the work. The bridge consists of seven 170-ft. steel spans, with three lines of trusses, carried on masonry and concrete abutments and cast-iron cylinder piers filled with concrete. The length of the bridge over all is 1,040 ft. 8 ins. and the width between footway parapets is 73 ft. Each of the two carriageways is 24 ft. wide and each of the two footways is 9 ft. wide, and is carried on cantilever girders riveted to the bottom chords of the outside trusses. The cylinder piers were sunk to rock from 70 ft. to 90 ft. below high water level by the pneumatic process. A maximum of 44 lbs. air pressure was employed for some of the piers. Work was carried on in 4-hour shifts until a depth of 75 ft. was reached, when the shifts were reduced to 3 hours, and at the maximum depth to 2 hours. It was found that the men quickly became exhausted and suffered great discomfort as soon as the air pressure exceeded 35 lbs.

CAISSONS SUNK BY OPEN DREDGING to a depth of 88 ft. below mean sea level were employed in founding the new bridge of the Bengal-Nagpur Ry. over the Rupnarayan River, India, which is a tidal stream. The bridge consists of seven 314½-ft. truss spans flanked on each side by two 108-ft. truss spans. The main spans were founded on steel caissons 88 ft. high, 63 ft. long and 22 ft. wide with semicircular ends. Each caisson was divided into three dredging chambers by two transverse partitions. They were sunk through a hard blue clay to a sand stratum. The total weight on this foundation bed was estimated to be 6.7 tons per square foot. The caisson chambers were filled with concrete and brickwork. The bridge was built under the direction of Mr. T. R. Wynne, Chief Engineer of the Bengal-Nagpur Ry., with Mr. J. H. T. Tudsbery, M. Inst. C. E., as Superintending Engineer.

THE CONSTRUCTION OF THE SIMPLON TUNNEL.

I.

The Tunnel and its Connections.

The construction of the Simplon Tunnel possesses unusual interest for the engineering world. In length this tunnel exceeds that of any other Alpine tunnel, and, consequently, that of any other tunnel in the world. The work of construction has been one of unusual difficulty in places. Finally, the project has had first and last a checkered history, and rumor has not yet ceased to foretell its possible failure. All these matters have been made familiar to engineers by repeated publication. Few American engineers, however, know with any exactness the history of the enterprise; its importance as a link in the railway transportation system of Southern Europe, or the extent of the difficulties which have confronted those who have set themselves to the task of carrying it to completion. To bring out these facts we have undertaken an account of the Simplon Tunnel work in all of its details. For the information from which this account has been prepared we are indebted to several sources, but the greater part has been collected for us by Mr. C. R. King, who personally visited and studied the work during the summer and fall of 1902.

Briefly described, the Simplon Tunnel extends from Brieg, on the Swiss side of the Lepontine Alps, to Iselle, on the Italian side. Its length between portals is 19,730 m., or about 12.3 miles. In plan it is a straight line, with the exception of a short curve at each end. Structurally it is a double tunnel, consisting of two parallel single-track tunnels, spaced 17 m. (55.76 ft.) apart center to center. At present only one tunnel is being constructed to the full section. This is known as Tunnel I. Tunnel II. is being opened up by a gallery some 2 m. (6.56 ft.) high and 3 m. (9.84 ft.) wide. This gallery is connected with Tunnel I. by cross-galleries spaced about 200 m. (656 ft.) apart, and serves for the transportation of material and for other services connected with the tunnel work. The entrance portals for construction purposes were opened on the line of the tangent extended, the permanent portals and the end curves being left for development at a later date.

HISTORY OF THE PROJECT.

The Simplon is one of the most noted passes of the Alps, and since 1806 it has been traversed by the Simplon Pass Road, built by Napoleon I. Projects for tunneling the pass have been numerous, the first one being inaugurated in 1853. Only a few of these projects, however, possess sufficient engineering interest to warrant specific mention. In 1857, Mr. Clo-Venetz proposed a tunnel 12,200 m. (7.5 miles) long, to extend from Grund at an elevation of 1,068 m. (3,503 ft.) on the Swiss side to Gondo at an elevation of 1,011 m. (3,316 ft.) on the Italian side. This project, it will be noted, was for a short tunnel pierced at a comparatively high level. It was followed by a project launched in 1860 by the French engineer Vauthier, which called for a tunnel 18,220 m. (11.3 miles) long, starting at an elevation of 743 m. (2,431 ft.) on the north side and terminating on the south side at an elevation of 623 m. (2,043 ft.). This was the first of the low level projects.

In 1875, the Simplon Co., which had been organized the year before, consulted Mr. Louis Favre, the contractor for the Saint Gothard Tunnel, regarding the best route for a tunnel through the Simplon. Mr. Favre proposed a tunnel 19,859 m. (12.3 miles) long, starting from near Brieg at an elevation of 600 m. (1,968 ft.) on the north side and terminating near Iselle, at an elevation of 644 m. (2,112 ft.) on the south side. The route of this project, like those of its predecessors, was under the lofty Monte Leone. Before anything further was done with it the engineers of the Saint Gothard tunnel had encountered the difficulties caused by the high temperatures due to the great depth of the rock strata penetrated. To court these same difficulties by driving the Simplon Tunnel under Monte Leone was deemed hazardous. When, therefore, the consolidation of the Simplon Co. and the Swiss Occidental Railway took place in 1881, and new studies for a tunnel through the Simplon were set on foot, a route was sought which would avoid tunneling under the great depths of Monte Leone. This route was found in 1882, and was laid down as shown by the accompanying map, Fig. 1. It called for a tunnel 20,000 m. (12.4 miles) long. In 1886, however, the railway company announced a new route, which reduced the length of tunnel to 16,000 m. (9.9 miles), but necessitated a passage at a much higher level than did the plan of 1882, and also necessitated a considerable length of approach line at each end, as is clearly shown by Fig. 1. In 1888, the company reverted again to the low level plan, and adopted the third route shown by Fig. 1. All of these plans were accompanied by geological studies of the strata penetrated, and altogether an enormous amount of information and opinion was accumulated. These data were all of decided aid in the work of fixing the final location, to which we will now turn attention.

In 1893, the Jura-Simplon Ry. Co. entered into a contract with Brandt, Brandau & Co., of Winterthur, Switzerland, to construct a tunnel from Brieg, on the Swiss side, to Iselle, on the Italian side of the Simplon Pass. The general route of this tunnel is shown by Fig. 1, and is practically the same route laid down by Mr. Louis Favre in 1875. Before being finally adopted this route and the tunnel plans were submitted by an arrangement with the Swiss and Italian governments to a commission composed of Mr. Colombo, an engineer of Milan, Mr. Francis Fox, M. Inst. C. E., of London, and Mr. Wagner, of Vienna. The approval of this commission established finally the engineering features of the Simplon Tunnel proper, but there yet remained many preliminary negotiations to be carried through.

The Swiss railway system on the north side of the pass terminated at Brieg, almost at the north portal of the tunnel. The Italian railway system on the south side of the pass reached, however, only to Domo d'Ossola, located some miles to the south of the southern end of the tunnel. Finally the tunnel was to be built by a Swiss company, and was located partly in Switzerland and partly in Italy. On Nov. 25, 1895, the Italian government negotiated a treaty with Switzerland, providing for the tunneling of the Simplon, and on the following Feb. 22, 1896, the Italian government entered into an agreement with the Jura-Simplon Ry., by which the railway was permitted to construct and operate a tunnel line from the Swiss frontier to Iselle, and by which the government was to build a connecting railway from

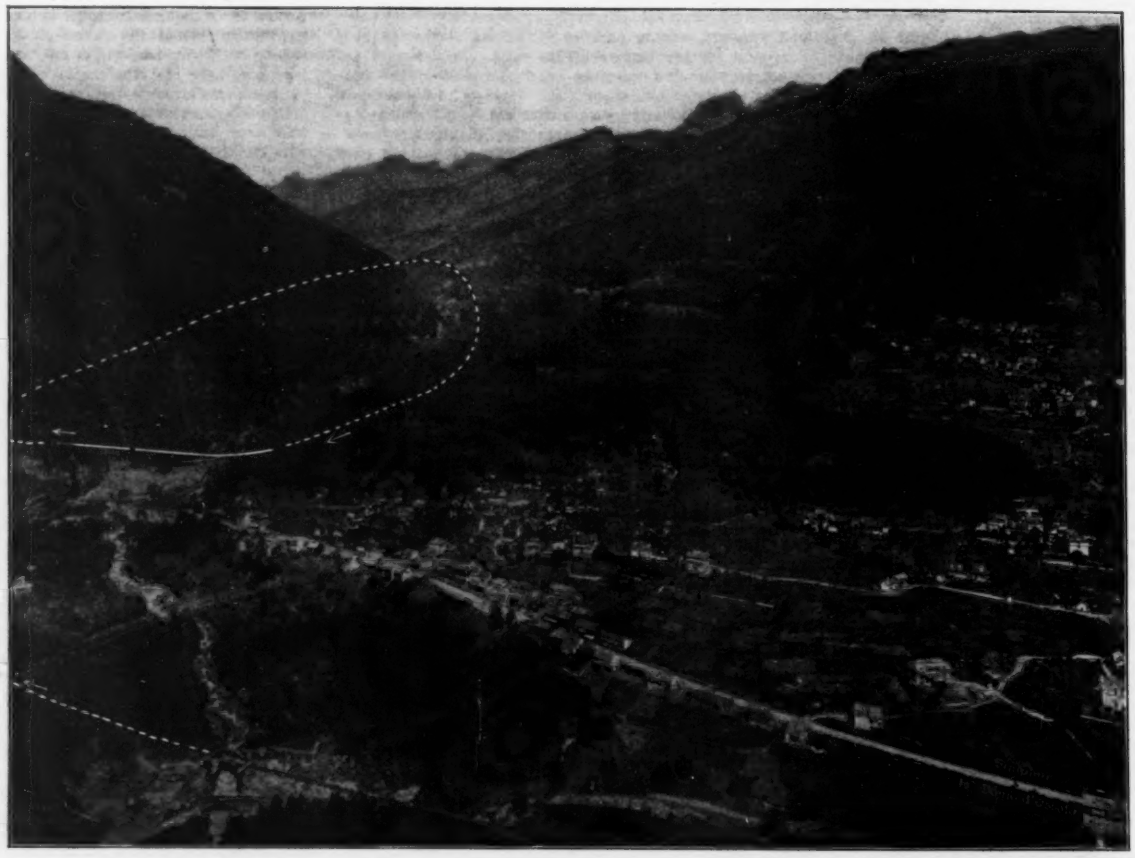

FIG. 5. VIEW OF THE CAIRASCA VALLEY AND VILLAGES OF VARZO, SHOWING ROUTE OF HELICAL TUNNEL ON THE DOMO D'OSSOLA-ISELLE LINE.

Domo d'Ossola to Iselle. The Jura-Simplon Ry. had already secured from the Swiss government permission to build and operate its tunnel line from Brieg to the Italian frontier.

RELATION OF SIMPLON TUNNEL TO EXISTING ROUTES.

At present Italy, through which lies the overland route to India as far as Brindisi, is connected by railway with France by the way of Modane and Turin by the Mont Cenis tunnel, and by the way of Belfort, Delle, Basle and Luzern by the St. Gothard tunnel, and thence to Chicasso. This second route makes a long detour through Switzerland, and at present the best time made upon it from Paris to Milan is 22 hours, and from Milan to Paris 21½ hours. The competing line (Mt. Cenis) from Paris is the Paris, Lyons & Mediterranean Ry., and this connects with Italy direct by Modane, the time taken to reach Milan being 19 hrs. 25 mins. Passing over the same route the weekly-limited Peninsular Mail, from London to Brindisi, whence the mail packet leaves for India, accomplishes the journey of 1,580 miles in 42 hrs. 10 mins., the longest time by ordinary train being 54 hrs. The time by the St. Gothard route exceeds this by from 1 to 8 hrs. Yet another route exists by the way of Marseilles and Ventimiglia, outflanking the Maritime Alps at the latter place, but this is not a sub-Alpine line, nor is it of importance as far as saving of time is concerned. The route by the way of the Mont Cenis tunnel is, therefore, the quickest for the south of Italy, but from London to Milan its time is about 27 hrs. 15 mins., whereas the St. Gothard line from Milan, via Switzerland, Germany and Belgium (Ostend) only requires 26 hours by the best time to reach London.

Between the two routes, the St. Gothard and the Mt. Cenis, there is sufficient deviation from a direct line betwen Paris and Milan to allow of a third or middle route, which would result in a saving of time. This line is supplied by the Simplon Tunnel route. Otherwise than as indicated it does not appear that any Swiss railway company will suffer by the competition of the new route. The construction of the Simplon Tunnel will, therefore, be to the especial benefit of the Paris, Lyons & Mediterranean Ry., to that of the Jura-Simplon Ry., which in 1904 will become the property of the Swiss government, and to that of the Italian Mediterranean Railway. The territory benefited will be French Switzerland and the whole of northeastern Italy (Piedmont and Lombardy). Already the numerous railway lines now projected or under construction between Genoa and Domo d'Ossola testify to the strong hopes which the Italians have of the future development of these large northeastern provinces.

The French railways now connect with those of Switzerland, in route to the north end of the Simplon Tunnel, at Geneva. The route is from Paris to Dijon, then by way of Bellegarde and Culoz, so as to outflank the Jura Mountains, to Geneva. To shorten this route, however, French engineers have already prepared plans for tunneling the Jura Mountains through the Faucille in the Department of Ain. This tunnel as planned, will be about 5 miles long and will cut the range at a maximum elevation of 1,900 ft. The grades will seldom exceed 1%. Besides the main tunnel there will be some 15 small tunnels on the cut-off. The saving in distance between Dijon and Geneva by the new line will be about 125 miles, and in time about 3 hrs. The time schedule beginning at Paris is estimated to be as follows: Paris to Dijon, 5½ hrs.; Dijon to Nantau, 2½ hrs.; Nantau via Faucille to Geneva, 1½ hrs.; and Geneva to Brieg, the Swiss end of the Simplon Tunnel, 3½ hrs., or a total of 13 hrs. from Paris to Brieg. From Brieg south through the tunnel to Milan the estimated time is 3 hrs. The new Simplon route with the Faucille cut-off thus brings Paris from 3½ hrs. to 5 hrs. nearer to Milan by rail, while the mail route from London to Brindisi is reduced to 1,400 miles, as compared with the present 1,580 miles noted above.

The foregoing explanation of the relation of the Simplon Tunnel route to those now existing between Europe, north and south of the Alps, makes fairly plain the purpose of its construction and the benefits which are expected from it.

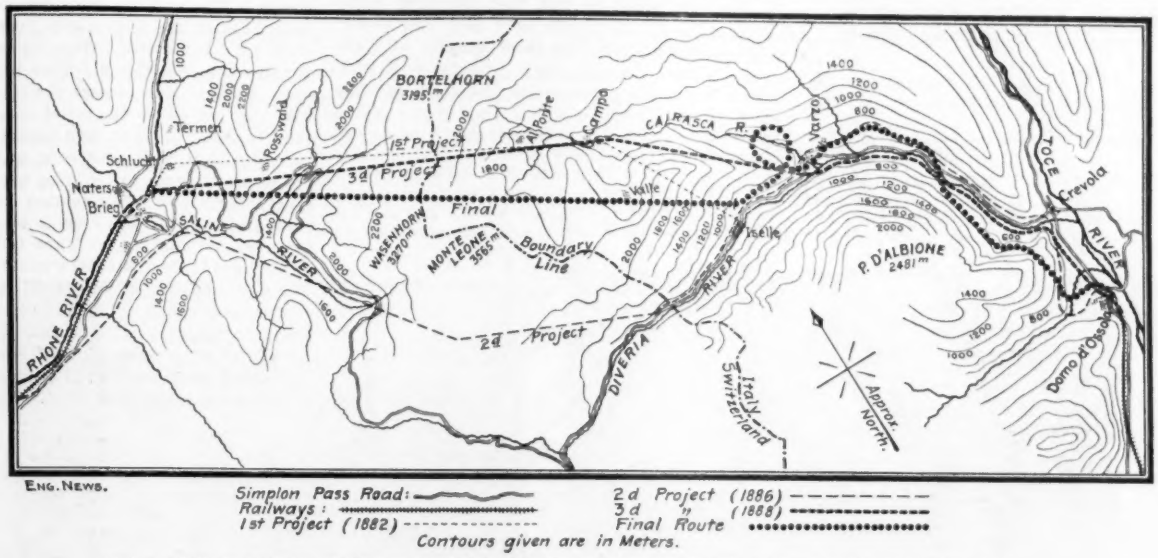

FIG. 1. MAP SHOWING ROUTES PROPOSED FOR THE SIMPLON TUNNEL FROM 1882 TO 1893.

ENGINEERING FEATURES OF CONNECTING LINES.

As previously stated, the northern terminus of the Italian railway system is at Domo d'Ossola, some miles south of the tunnel end, at Iselle, and in its agreement with the Jura-Simplon Ry., the Italian Government contracted to build this necessary connecting link. It has in reality gone much further than this, and is also building a new line from Milan to Domo d'Ossola. These new lines, with their connections and branches, are shown on the accompanying map and profile, Figs. 2 and 3. This new railway involves numerous engineering features of interest in the construction, and as it is an essential part of the Simplon route some of its more important works will be described before proceeding with the tunnel construction proper.

By reference to the map, Fig. 2, it will be seen that the new line from Milan to the Simplon Tunnel starts at Gallarate, on the existing line, follows the west shore of Lake Maggiore by way of Arona and Feriolo and thence proceeds north to Domo d'Ossola and Iselle. The profile of the new railway, as compared with those of the existing lines, is shown by Fig. 3, and illustrates in a striking manner the reduction in grades which will be secured. Briefly stated, the grades of the existing line are 1% and occasionally 1.6%, while those of the new line do not exceed 0.6%. The new

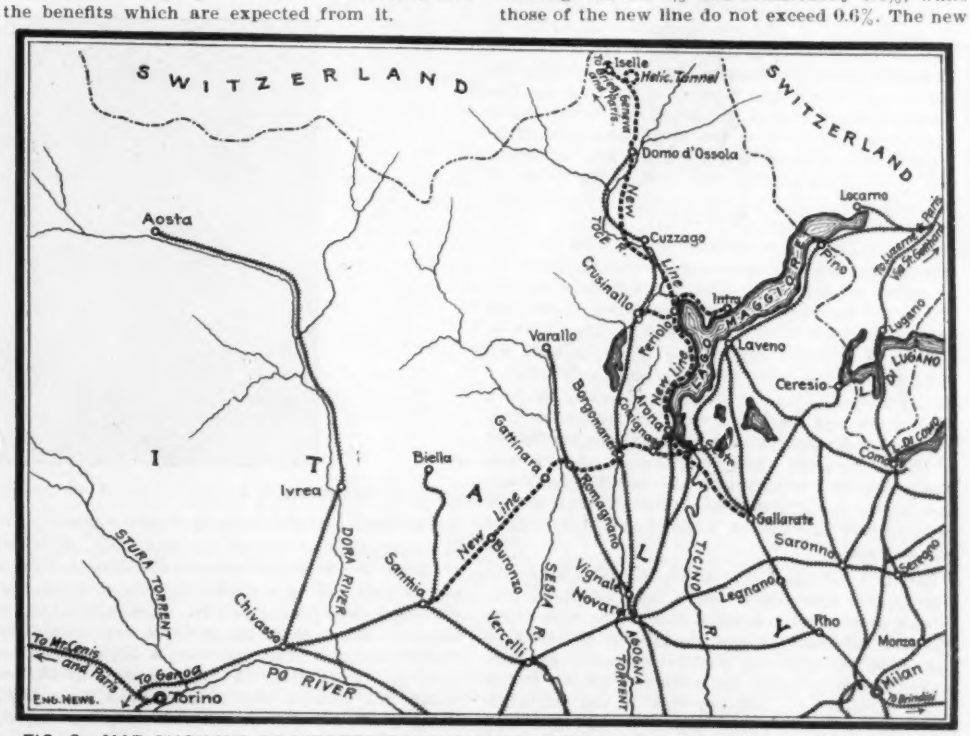

FIG. 2. MAP SHOWING PROJECTED RAILWAYS TO CONNECT WITH THE ITALIAN END OF THE SIMPLON TUNNEL.

line is now under construction from Arona north. There is also under construction a line from Santhia to Romagnano, which will ultimately be extended, as shown by the map, to Arona. This last line has one long tunnel which is being constructed from two portals and three shafts. It is, however, the construction of the line from Arona to Iselle with which we are chiefly concerned here, and for the purpose of this description the work on this line is divided into two sections.

ARONA TO DOMO D'OSSOLA.—Construction work on the section from Arona to Domo d'Ossola is being carried on at numerous separate points, the plan being to complete the difficult parts first and then fill in the links of easy construction. The roadbed and permanent way structures are all being built for two tracks, but only one track will be laid for the present. The track will be laid with 73-lb. rails. It will be noted from the map, Fig. 2, that the new line crosses the older one at two points in the deep gorge of the Toce River. It may be noted here that a navigable channel is now projected to connect Domo d'Ossola with Feriolo and Lake Maggiore.

Perhaps the most notable piece of construction on the section of line now under consideration is the tunnel at Farragiana. There are a number of smaller tunnels between Auria and Feriolo, but the one at Farragiana is some 12,000 ft. long. The material penetrated at the south end is very hard porphyric rock, and at the north end is a mica-schist rock. Compressed air drills and dynamite are used in excavating the rock. The form of timbering employed for the heading is rectangular and for the enlargement is radial.

The total saving in distance effected by the new line from Domo d'Ossola via Arona to Milan, is 11 miles, as compared with the present route by Novara. As regards traffic, greater loads and higher speeds will both be possible. The *Train de Luxe* will average, taking the mean in both directions, a little over 40 miles per hour, instead of the present 31 miles per hour average by way of Novara and Guzzano; and for freight service the new and strengthened lines will allow of loads of 1,035 to 1,210 tons, in place of the present maximum load of 528 tons. To provide for these new traffic possibilities the Italian Mediterranean railway line has built a number of 77-ton freight locomotives.

DOMO D'OSSOLA TO ISELLE.—The new line from Domo d'Ossola to Iselle leaves the old terminus and sweeps around the town, under the Simplon road and across a plain, in a detour to the west, in order to reach the range of hills where the long climb to Iselle is begun. For a short distance the railway line leaves the high road and water courses which it has followed from Gallarate. To the northwest of Preglia it is carried through a short tunnel below Bosco, whence it emerges on the side of the steep cliffs above the River Diveria. From this point to the mouth of the Simplon Tunnel it follows the valley; the river and the high road crossing and recrossing the latter, according as the configuration of the country necessitates. The topography of this valley is extremely diversified; sometimes the valley is narrow with vertical sidewalls, sometimes it opens out into fertile basins, and sometimes it is of a very savage and dangerous appearance, with immense boulders and half-detached cliffs apparently ready to topple over and roll down the slopes to join the great masses of rock which have already taken this journey, and now lie in the river below. As a bit of wild scenery this valley is magnificent, although the eight miles of it is but a small attraction as compared with the stretch of wild desolation on the Italian side of the St. Gothard Tunnel. Its professional interest to the railway engineer lies in the fact that almost every imaginable form of engineering work in railway construction has been necessitated. There are open cuttings, edge cuttings, along the sides of cliffs, built-up or artificial tunnels and arcades, long high embankments, bridges, tunnels and viaducts.

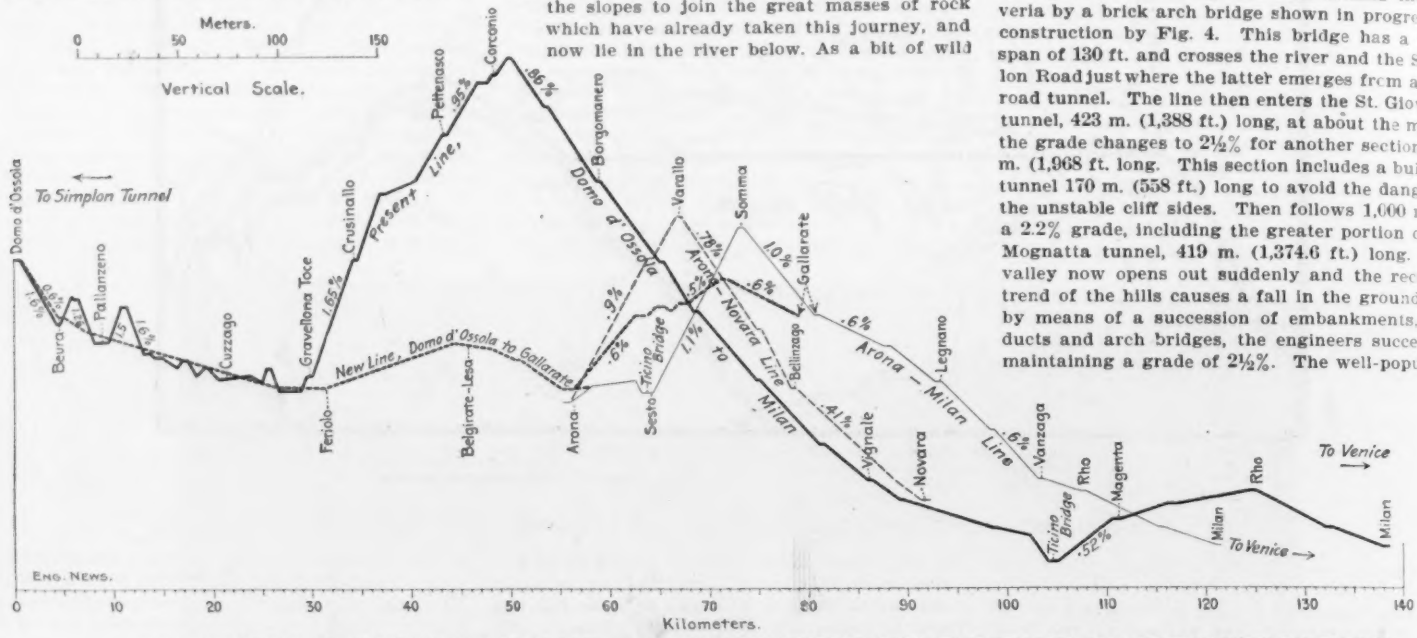

FIG. 3. PROFILES OF EXISTING AND PROPOSED RAILWAYS CONNECTING WITH THE ITALIAN END OF THE SIMPLON TUNNEL.

Across the plain at Domo d'Ossola, which is intersected in all directions by water courses, there is a formidable stretch of embankment. A bridge of seven brick arches crosses the Bogna torrent and is followed by a roadway arch over the railway and by several culverts. The railway to the Simplon Road crossing is level for 1,006.6 m. (3,300 ft.). and then rises on a 2½% grade for 2,444 m. (8,016 ft.). A level stretch of 640 m. (2,099 ft.) follows, and is succeeded by a 2½% rising grade for 200 m. (656 ft.), crossing an iron box-girder bridge carried on granite piers. This is the only example of iron bridge work on the line, all the other bridges having stone masonry approaches and brick arch spans. The next 860 m. (2,821 ft.) rises on a 2.2% grade and includes the Bosco tunnel 681 m. (2,234 ft.) long and parapet construction along the sides of the steep cliffs above the Diveria.

The next section of the line is 900 m. (2,953 ft.) long and rises on a 2½% grade including a tunnel 114 m. (374 ft.) long cut through a projecting bluff. On the succeeding 1,200 m. (3,937 ft.) the rise is 2.27%, and the line follows the slopes of an open part of the valley and then crosses the Diveria by a brick arch bridge shown in progress of construction by Fig. 4. This bridge has a clear span of 130 ft. and crosses the river and the Simplon Road just where the latter emerges from a long road tunnel. The line then enters the St. Giovanni tunnel, 423 m. (1,388 ft.) long, at about the middle the grade changes to 2½% for another section, 600 m. (1,968 ft. long. This section includes a built-up tunnel 170 m. (558 ft.) long to avoid the danger of the unstable cliff sides. Then follows 1,000 m. on a 2.2% grade, including the greater portion of the Mognatta tunnel, 419 m. (1,374.6 ft.) long. The valley now opens out suddenly and the receding trend of the hills causes a fall in the ground, but by means of a succession of embankments, viaducts and arch bridges, the engineers succeed in maintaining a grade of 2½%. The well-populated district of Varzo then follows, with a roadside station, on a level section 610 m. (2,001 ft.) long. The Cairasca stream here empties into the Diveria and has to be crossed by a brick arch span of 104 ft. The view, Fig. 5, shows the villages of the Varzo and the Cairasca valley. The Simplon Road comes into the view at the lower right-hand corner, and reaches diagonally across the valley, crossing the Cairasca at the extreme left hand by a masonry arch bridge. The crossing of the same stream by the new railway is effected just above the small road bridge near the bottom of the engraving, and here is located the 104-ft. arch span noted above.

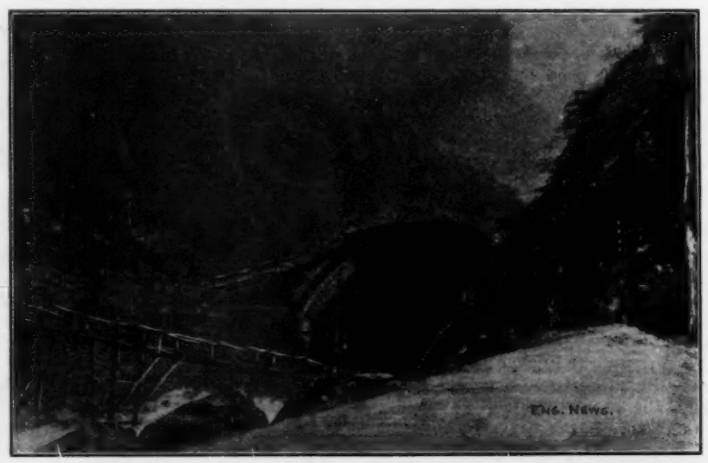

FIG. 4. SKEW ARCH BRIDGE OVER THE DIVERIA RIVER ON THE DOMO D'OSSOLA-ISELLE LINE.

From the bridge the grade is 2½% for 640 m. (2,100 ft.). At this point the Simplon Road, curving around under the Trasquera cliffs, crosses the route of the railway, which passes under the road and enters the 3,000 m. (1.8 miles) helical tunnel of Varzo, which is on a 1.8% rising grade throughout. As indicated by Fig. 5, the tunnel passes up the valley of the Cairasca, curves to the right underneath the stream and returns emerging on the opposite side of the stream from

the entrance portal, but further upstream, and at a higher level. The line then crosses the Cairasca a second time by bridge and enters the steep cliffs of Trasquera by tunnel. The Varzo tunnel is now about one-third completed counting both headings. The progress of work has been slow, owing to the infiltration of water from two small streams which cross the tunnel axis. The work has not yet penetrated under the larger Cairasca torrent.

The entrance to the Trasquera tunnel is high above the Simplon Road. From the upper portal of the Varzo tunnel the line ascends on a grade of 1.9% for a distance of 1,500 m. (4,921 ft.). This section includes the greater part of the Trasquera tunnel, which is 1,724 m. (5,656 ft.) long. From this tunnel for 818 m. the line is level, and includes a heavy rock fill. The unstable character of the cliffs along this section necessitates a considerable length of built-up tunnel, and there is also a tunnel through a rocky bluff which emerges immediately in front of the south entrance of the Simplon Tunnel, and only 60 ft. distant. The portal of this tunnel, as seen from the Simplon Tunnel entrance, is shown by Fig. 6. Here the Italian line to the Simplon Tunnel ends.

The distance from Domo d'Ossola to Iselle by the line described is 18,679 m., or 11½ miles, and the total rise is 357.5 m. (1,173 ft.) On this 11½ miles of line there are seven tunnels having an aggregate length of about 6,500 m., or over 4 miles. The view, Fig. 7, shows the village of Iselle, with the Simplon Road on the right, and, in the distance, Mount Seehorn, one of the triangulation stations for the location of the tunnel.

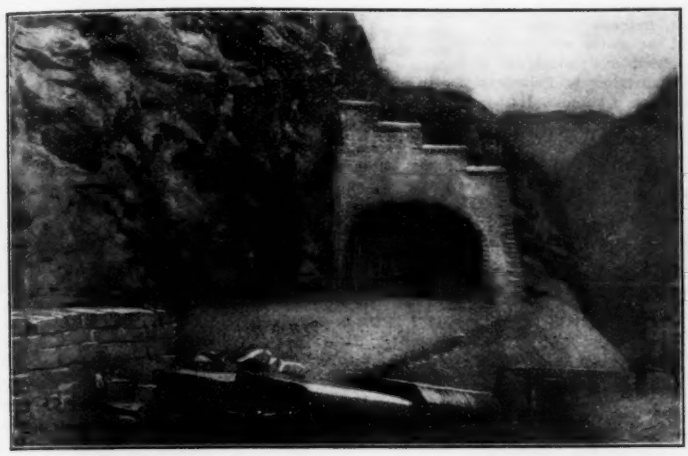

FIG. 6. VIEW SHOWING PORTAL OF LAST TUNNEL ON THE DOMODOSSOLA-ISELLE LINE FACING THE SOUTH PORTAL OF THE SIMPLON TUNNEL.

FIG. 7. VIEW OF ISELLE, SHOWING THE SIMPLON ROAD AND MOUNT SEEHORN IN THE DISTANCE.

THE USE OF MOTOR VEHICLES FOR MUNICIPAL PURPOSES IN ENGLAND.

The motor vehicle has, as some of our readers are doubtless aware, come to be quite extensively used in England for such municipal purposes as the collection of dust and refuse, street sweeping, street sprinkling, etc. In a recent issue of the "Contract Journal" of London we find two very interesting accounts of experience with motor vehicles for various municipal services, and from them we abstract the following portions of most general interest:

Motor Vans for Municipal Purposes.

By T. W. Higgins.*

The question of providing mechanically-propelled vehicles for the public service is one which should have the most careful consideration of all municipal engineers, especially those whose work lies in our large cities, where congestion of traffic in narrow roadways, and nuisance caused by horse droppings along the main lines of thoroughfare, are felt to be sources of danger and discomfort to all who use the streets. The author is strongly of opinion that, should the cost of working motor vehicles even approximate to that of horse-drawn ones, every local authority responsible for cleansing the streets should encourage their use, both on sanitary and economical grounds. More particularly should this be the case in populous London districts. A whole army of men and boys are there engaged in merely picking up horse droppings; and the public are so accustomed to the sight, that the enormous expense entailed by it is hardly ever realized. But if motor vans and carts were substituted for only the horse-drawn vehicles now used for the purposes of the city and borough council within the metropolitan area, an appreciable saving in the matter of street cleansing would ensue.

*Borough Surveyor of Chelsea, London, England.

The author has recently ascertained from a veterinary book that the excreta from a horse varies from 38 lbs. to 49 lbs. during the 24 hours, the greater portion of which must find its way into the streets. He has calculated that the horses in use by his council (the sanitary authority) distribute about the borough—one of the smallest in London—three-quarters of a ton of manure per day. For how many tons of horse manure deposited in public streets are the sanitary authorities of London responsible? Apart from the dirtiness of the creature, some account should also be taken of the very heavy wear and tear to the road surface caused by the number of feet attached to him, which would to a great extent be obviated if mechanically-propelled vehicles were in use. What has been termed the "three hundredweight hammers of iron-shod horses' feet" probably wear out every road twice as quickly as the iron-shod wheels of the vehicle which they draw; and, in addition, as I have just mentioned, the horse is in itself the cause of a great portion of the offensive matter lying in the streets of towns.

In the summer of 1900 the author had two motor vans built to the following specification:

BODY.—The framing to be made of oak, the floor and sides to be of well-seasoned pine, the whole well supported with iron work.
COVERS.—To be of sheet steel, arranged so that they can be all removed or separately slid.
UNDERFRAME.—To be of channel steel, 6 × 2½ × ⅝ ins., well stayed and riveted up throughout.
TIPPING.—To be worked by double cut steel racks and pinions, giving sufficient purchase to enable one man to perform the operation.
STEERING.—To be done by means of pivoted axles by worm and wheel gear.
GEARING.—To be of the finest bronze with machine-cut teeth, arranged for two changes of gear, which can be altered while the vehicle is in motion from the driver's seat. Both gears to be worked by a single lever, the wheels to run in an oil bath. With the engine running at 400 revolutions per minute, the fast gear to be equal to six miles per hour, and the other four miles per hour.
ENGINE.—To be compound, having cylinders 3½ × 6½ × 6 ins. stroke. To be fitted with link motion, and have very large wearing surface. The low-pressure cylinders to be capable of being worked high pressure for starting or getting out of bad places. The engine to be entirely cased in and running in an oil bath.
BOILER.—To be coke fired, and have 84 sq. ft. of heating surface, and arranged for a working pressure of 200 lbs. per sq. in., and tested hydraulically during construction to 420 lbs. It is to be arranged so that the outside shell can be taken out for cleaning purposes.
FIRING.—The bunkers to be arranged each side of the boiler, within easy reach of the driver's seat.
FEED-WATER HEATER.—A large feed-water heater to be fitted, consisting of a copper coil enclosed in a specially-designed case, the exhaust steam being passed through the case, and the feed water heated to a temperature of about 180° F.
WATER-TANK.—To have a capacity of 100 gallons, which is to be sufficient for a run of about 12 to 15 miles.

These motors have been working since 1900, and are found to be most useful. The author has also had at work a steam motor van which has a frame built to take either a tipping body or water tank (700 gallons). This machine is one which has also proved very useful and economical. It cost $2,750, which included both bodies, and a general guarantee against defects for the twelve months following delivery. It had been in work for some two years for various persons before the author purchased it. The use of such a vehicle is greatly to be recommended, and the author finds that by a simple arrangement he can fasten a horse broom—or rather a revolving broom made originally to be drawn by a horse—to it, and thus water and sweep at the same time.

There are several motors used in London for municipal purposes, and the following are in use in the provinces. The Liverpool Corporation has seven of the Lancashire Motor Co.'s vans. Six of these are in constant use for the removal of house refuse, each van being provided with a trailer, which is found to work without any trouble. Though used generally for removing house refuse, every opportunity is taken to send a load of materials, etc., back by the motors to some place near where they are working, as it is the extra loads so taken which make them pay. The city engineer has had one motor in use for some years, and his experience with this vehicle induced him to order six more. In Liverpool cartage by motor vans is taken as a matter of course. The Burnley Corporation have one of Messrs. Coulthard's vans. It was originally intended to carry ashes to their bacteria beds, which are some distance from the town; but on its journey it had to cross a country bridge which was not in a good state of repair, and consequently the County Council objected to its weight. The corporation have, therefore, to restrict its use to their own borough. It is in use for general cartage. The Blackburn Corporation have one of the Lancashire Motor Co's vans, which is used to carry clinker to the sewage farm. It has worked very satisfactorily for a year, and has lately been running about 36 miles a day. They consider it a great success, and have another van on order from the same makers. The author saw the motor carrying a load of 4¼ tons over very rough and hilly roads, but as the roads in most of the Lancashire towns are very rough and hilly, the motor makers look upon that as the normal condition under which their vehicles work. There is no doubt that this van, having to go long journeys, is worked to great advantage. It is running most of the time at a pace which no cart horse could keep up, and the time spent in loading is very short. The Bradford Corporation have a Milnes lorry. It is used in the tramway department as a "tower" van to attend to the overhead electric wires, and it is regarded as successful in working. Being a petrol-driven van, it is not consuming fuel when standing in the street to allow the wires to be repaired. The Newcastle Corporation are also using a similar tower van for a similar purpose. The Glasgow Corporation also use a Milnes lorry for collecting house refuse; but the superintendent seems to think that the time such a vehicle has to stand about being loaded is not favorable to economy. One of Mann's patent carts has been supplied to the Corporation of Douglas, Isle of Man. The Norwich Corporation have a wagon made by the Yorkshire Patent Steam Wagon Co., which is used for general work and for cartage to their sewage farm. The Acton Urban District Council, the county borough of Bournemouth, and the Corporation of Bootle use steam wagons made by Thornycroft's Steam Wagon Co., the latter corporation having two vans.

Motor vehicles have many advantages, but the chief is, no doubt, the speed at which they can work; and this is the reason why they must appear costly when used for street cleansing or dust removal in a small district. When used for these purposes the wages of the skilled mechanics who drive them adds greatly to the cost. These men only drive the motor; they cannot leave their vehicle to load it. If the motor driver were able to walk alongside his vehicle like a horse carman does when the slop van is moving along and sweep up the slop, or if an unskilled man could drive a dust motor and leave it unattended while he collects the dust, the motor cartage by the council would be cheaper than horse cartage. But at present this cannot be done. Thus it is found that a motor which

has to crawl along from door to door for dusting, or from heap to heap for slopping, is being used in the most unprofitable manner possible.

The author is convinced that in a large district, or where the dust and slop shoots are situated at some distance from the place where the refuse is collected, motor vans will be economically used for this purpose; but when used for general cartage or watering, where it is possible to get 18 or 20 hours' work out of the machine per day, they will be found to be a valuable addition to a borough engineer's plant, and well repay the large capital outlay expended upon them.

Mechanical traction has come to stay. It is completely altering the social habits of the so-called upper classes; all the large business firms are advantageously adopting this means of transport, and municipalities have no cause to lag behind.

DISCUSSION.

Mr. A. E. Collins (Norwich) said he had used a steam motor now for some little time, and as long as he could keep it running it was an economical machine. But he found that constant vibration made it very difficult to keep the joints tight, and repairs meant loss of work. He did not doubt but that was a difficulty which would be got over. He found that the most economical use of the motor was for street watering, where it could be kept going, and for carrying material to the sewage farm. For ordinary cartage for short journeys he did not think it paid.

Mr. Winter (Hampstead) hoped Mr. Higgins would supplement his paper with particulars of cost as compared with ordinary horse haulage. Like Mr. Collins, he found with the motors which he had had in work for 18 months that there was a considerable waste of time for repairs. He found with his two motors it amounted to 20%. That was a serious drawback. The cost had amounted to something like $350 a year. He found the most advantageous use to which he could put them was street watering, and the haulage of materials. He had worked out some figures as to the haulage of road metal, and he found, with the disadvantage they had suffered during the last 12 months with heavy repairs, the cost of motor haulage worked out at 35 cts. per ton as against horse haulage at 39 cts. per ton. Even there they got economy, but with further improvements and a suitable boiler the economy ought to work out much more beneficially.

The President said he found, like the previous speaker, that while the motor was at work it did excellent work. An enormous area of wood paving could be cleansed by that machine during the night, but there were disadvantages—one set from frequent breakdowns, chiefly of a trifling character, but necessitating repairs, and put the routine of their work out of gear, and the other set the objection to the noise. The latter objection proved so powerful that he had to abandon the motor for night work. Although it did not make so much noise as an express wagon or an omnibus, yet in the quietude of the night the noise of the motor was very apparent, accentuated as it was by the silence. He had no doubt that an ordinary vehicle going down an ordinary road in the middle of the night would draw 50% of the people out of their beds to see what was the matter. Then in designing the machine they did not calculate the different strains of the working parts. The india-rubber squeegee, which cost $130 and which he had behind the broom, revolved at such a rate that, though it did excellent work, it would have been worn out in a fortnight. That was a rather expensive luxury, so he had to abandon it. He had a second body made to it, so that he could take the water tank off when he was not using the motor for street watering, and he then put on an ordinary 5-yd. cubic body for carting sand, and that worked very well. There was a great difficulty in putting down the actual cost as compared with horse work. They divided up the work of the motor so much that it was a very difficult matter, unless they had got a large staff of idle clerks sitting round for some work to come in—and that was not his case—to go into these matters with sufficient detail to give figures to rely upon. He believed with an ordinary motor they would have difficulty in getting makers to keep it in repair under $375 or $400 per annum, as the breakages and breakdowns were so frequent.

Report on the Use of Motor Vehicles by the Bermondsey Borough Council, England.*

By Robert J. Angel.†

Mr. Robt. J. Angel, borough engineer and surveyor, has just submitted to the Bermondsey Borough Council a very exhaustive report with respect to the use of motor vehicles for the Council's work. He says: "There is not the least doubt that mechanically propelled vehicles will be very generally used in the near future, and the cleansing of towns should be rendered considerably easier, and the towns themselves far more sanitary." He has collected from several municipal authorities the following particulars. Blackburn has two motors built by the Lancashire Steam Co., at a cost of £550 each. The first year's maintenance was about £75 per motor. They are used for conveying clinker, etc., to sewage works 5½ miles distant, and carry 4½ to 5 tons. The cost of fuel, etc., is 23s. per week per motor. Liverpool has six motors built by the same makers, and cost £524 each. They are used for the collection of house refuse, going an average journey of three miles when loaded, and carrying four tons. These motors work 16 hours per day. The cost of 12 months' working, including wages, maintenance, repairs, and £1 per week depreciation, amounts to £243 14s. 8d. per motor. Westminster has three of Thornycroft's steam motors, costing £750 each, with interchangeable bodies for dust collection and street-watering. The capacity of the body is 7½ cu. yds. The motors are working continuously day and night. Burnley has one compound steam motor which cost £600. The cost of the first year's maintenance was £35. This motor is worked nine hours per day, and was under repair for 20 days. The driver is paid at the rate of 7d. per hour. Cost per week: 7½ cwt. of fuel and one gallon oil equals 13s. 6d. per week. For short journeys it is no improvement on horse cartage. Kensington has a Thornycroft's motor, which cost £725, with two interchangeable bodies for watering and cartage, also a revolving brush or squeegee. Glasgow has a Milnes-Daimler motor to carry three tons, which cost £585. It was not a success in the collection of house refuse on account of the nature of the work, too much time being taken in the leading of it, so that the motor was not advantageously worked. Lambeth tried one motor for a month hauling house refuse from Brixton to Belvedere road, but the experiment did not prove a success. Hampstead has two Thornycroft's steam motors. They were obtained for dust collection, as the destructor is two to three miles outside boundary. The result, compared with horse haulage, did not work out economically even with the use of trailers with the motors. For some time motors have been used for street watering and haulage with distinct advantage, each motor doing the work of four horses and carts.

Mr. Angel gives the following approximate prices for the various types of motors specified: Thornycroft's, £750; Lancashire Steam Motor Co., £645; Straker Steam Vehicle Co., £665; Savage Bros., £625; Coulthard and Co.'s, £650; Clarkson's, Limited, £461 to £497; Milnes-Daimler petrol motor, £550; Foden's, Limited, £640. The full estimate of the first cost of a motor is given as follows: Cost of average motor, £600; add for trailer, £50; motor shed, say, £100—total, £750. No provision is made for land for sheds. Estimated cost per annum: repayment of loan of £750, spread over 12 years at 3½% per annum, annuity principle, £77 12s. 2d.; maintenance of motor, £60; ditto trailer, £5; depreciation of motor, say, £30; fuel, oil, etc., at £1 per week, £52; insurance and water, £10—total, £234 12s. 2d. Mr. Angel finds that in slow collection as compared with motors there is a difference in favor of collection by horse haulage of 1s. 3d. per cu. yd., and in dust collection there would be a difference in favor of collection by horse haulage of 6 5/6d. per cu. yd.

It is different, however, in regard to street watering and mechanical (motor) sweeping. The engineer says:

It is for this class of work that motors would most likely prove more economical than horses, as they would be constantly at work. A motor gives the best results when taking a heavy load over a long distance. When a considerable proportion of the time is taken up in loading and unloading compared with the time the actual transit takes it is extremely doubtful if motors would pay, and, in my opinion, where the journey does not exceed a mile the advantage of motors is practically nil; but on street watering and sweeping the motor would be continually at work. I am unable to give any comparison of cost of this work as performed by horses and motors, as the latter would only be occupied during a portion of the day on sweeping, doing other work throughout the remainder, and I have no definite data to base the estimate upon.

The following statement is made by the borough engineer of Kensington:

Our motor is used for sweeping, washing, and watering. It sweeps 14,000 yds. super of wood paving per hour, distributing the water once, or about half the area if the water is applied twice. It will wash twice, and cleanse once (with the squeegee attachment), 7,500 yds. super per hour, including refilling the water-tanks every 2,500 yds. The Council are so satisfied with the work performed that another motor is being purchased. It is proposed to work two motors night and day, doing the work of nine horses cleansing during the night, and of six horses watering during the day.

The surveyor to the late Strand Board of Works used motors for street cleansing at night and dust collection during the day, and states that, by so doing, the work of three dustvans and two water-vans was done with one motor, showing a saving of £170 per annum per motor, but, in his report, he makes no allowance for depreciation of the motors, and the return is based upon a period of seven weeks only. Although there would not be such good results in Bermondsey on account of the difference in the class of roads, I am of opinion that if the Council decided to scavenge their main roads during the night it would be a distinct advantage to use motors with a sweeping attachment and a water-tank body, working the motor two shifts of 10 hours each, the day portion being occupied either by street-watering or general cartage. As regards general cartage, the majority of journeys are too short for advantageous work for motors, but it would be better to utilize them thus rather than keep them standing idle when not required for watering. Another point should also be kept in view, that although there has been no snowfall of any consequence for the last two years, should a heavy fall take place, great advantage would be derived from a snow plough attached to a steam motor, which would effectively and expeditiously deal with a fall of several inches.

Particulars of three sweepers and elevators are given as follows: (1) A sweeper made by James Briggs, of Idle, near Bradford, has been used by the Liverpool Corporation. The machine is worked by one man and two horses, and consists of a covered van, with a rotary broom 5 ft. wide at the back, which sweeps the refuse into pans of the same length as the broom. The pans are attached to an endless belt. Both broom and elevator obtain their rotary motion from cog attachment to the hind wheels of van. The refuse is delivered into a shell inside the van, which when full can be withdrawn and replaced by an empty one, so that the machine can be kept constantly at work. The van does not tip, but has to be emptied at the side, the body having to be scraped out. The cost of the machine is about £250. (2) Messrs. Wadkin, of Leicester, have a machine adapted to be used with a horse broom. The ordinary rotary broom, set as usual at an angle, sweeps a track 6 ft. wide, the refuse is picked up from the end of the broom, and, by means of an elevator, conveyed into a van, the horse of which assists to draw the broom and elevator; a man sits on the machine to control it under present arrangements, while the carman in charge of the van attends to the two horses. The van, when loaded is replaced with another, or the machine can be employed as a broom only until the van returns. The machine dispenses with the man sweeping into the scoop behind the van, so that there is an actual saving of labor and a large saving of comfort to the public by having the slop directly removed from the road. The machine could be used in combination with a motor collector. (3) There is an American sweeper and collector made to scrape and pick up manure, paper, etc., worked by one man. It is known as Haerst's patent. The sweepings or scrapings are conveyed into a receptacle which can be emptied in the side roads when full for the vans to pick up. These machines would be useful for orderly-boy work, but the idea of tipping the sweepings into a side street again does not commend itself. At present they are only made to sweep 2 ft. 6 ins. in width. No. 1 (scraper only) costs £25, and is only suitable for asphalt; No. 2 (sweeper only) costs £26, and is suitable for asphalt and wood; No. 3 (scraper and sweeper) costs £31. The receptacle holds 3 cu. ft. Several of these machines are in use in the provinces. The patentees are considering the question of constructing larger machines.

Mr. Angel calls the attention of the committee to a patent motor gully-cleansing van made by the Lancashire Steam Motor Co.. It consists of a steel tank body, having a capacity of 1,150 ga..ons. The body is divided into two compartments, one for clean water (670 gallons) and the other to receive the mud and refuse from the gullies (480 gallons). A steam lifter is mounted on the top of the mud-tank, and attached to this is a hose, which is lowered into the gully; the steam from the boiler is then turned on, and the contents of the gully lifted into the back compartment. After the gully is empty it is filled up with fresh water from the front compartment. When the back compartment is full and the front empty, it would have a load of about four tons. The wagon is tipped in the ordinary way by a screw tipping gear. The van can be used as a water-van of 1,150 gallons capacity for ordinary street-watering, or a sewer-flushing valve could be fixed. To use same as a water-van the sluice door at back is tightly secured, and a valve is lifted by means of a handwheel. This connects the two tanks, the spreader being worked by levers from the driver's seat. The body can also be removed, and an ordinary refuse body fixed.

In conclusion, Mr. Angel is of opinion that it would not be economical for this Council to purchase motors for the collection of slop or dust, but that good results would be obtained by employing motors for street watering and sweeping, which would cost about £750 per motor.

*Reprinted from the "Contract Journal," July 15, 1903.

†Borough Engineer and Surveyor, Bermondsey, London, England.

THE HAMMER-FENNEL INSTRUMENT FOR STADIA WORK.

By Horace Andrews, M. Am. Soc. C. E.*

For various projected improvements, maps showing the relief of the land by contour lines are coming more into use as their value is appreciated.

Much ingenuity has been shown in devising instruments to facilitate the work of determining the heights and horizontal locations of the numerous points from which contour lines are deduced. Many of the contrivances invented abroad are ingenious, but seem cumbersome and unpractical to the American engineer, who is accustomed to instruments that can withstand a good deal of rough usage. The firm of Otto Fennel's Sons, of Cassel, Germany, has for a number of years constructed an instrument, known as the "Wagner-Fennel Tachymeter," which is quite extensively

*51 State St., Albany, N. Y.

used abroad, notwithstanding its complexity and the consequent care that must be given to keep it from damage. A description of this instrument may be found in Staley's "Gillespie's Higher Surveying."

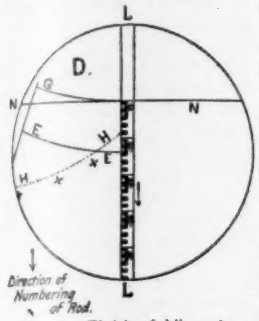

Fig. 1. Field of View in Hammer-Fennel Tachymeter.

For eight years Prof. Hammer, of the Technical Institute of Stuttgart, has labored to perfect a contrivance that would accomplish the results of Prof. Wagner's, and do this without the cumbersome scales and complex construction of the Wagner - Fennel instrument.

With Fennel's coöperation Prof. Hammer has at length devised the very ingenious instrument known as the "Hammer-Fennel Tachymeter Theodolite."

A brief description of this latter instrument will be of interest to many engineers. It is especially designed for determining differences of elevation and the horizontal distances of points with rapidity and without subsequent computation. The instrument is truly a "tachymeter;" rapidity and accuracy are desired, but the highest attainable precision is not sought. The location of points by stadia methods is a subject so fully described in text-books of surveying that the theory need not be referred to here. One detail not often mentioned, however, may be alluded to. By the use of the "Porro" combination of lenses in the telescope, stadia distances can be reckoned from the center of the instrument, and not from a point in front of the object-glass, as is usual with our instruments.

This contrivance of an Italian engineer has been in use in Europe for about fifty years. The Porro telescope is used in the Hammer-Fennel instrument, although it is not an essential part. It gives an inverted image, which is not usual with American instruments. The whole object of the telescope is to enable rod readings to be made. This can be accomplished to advantage with the inverting eye-piece, which renders better optical qualities possible with a telescope of given length.

Let us first consider the determination of a horizontal distance by usual stadia methods. The portion of the rod, held vertically, that is comprised between the stadia wires is observed and the vertical angle is read. The rod's horizontal distance from the zero of measurement, the point in front of the telescope, is then obtained by multiplying the rod reading by a constant, usually 100, and this product by the square of the cosine of the angle of elevation. With the Hammer-Fennel instrument the stadia-wires are made to approach one another, automatically, as the vertical angle increases, so that the rod reading, multiplied by 100, will give the correct horizontal distance from the center of the instrument.

The reading of vertical angles is entirely dispensed with, and in fact the instrument has no vertical circle unless one is desired for other purposes.

To obtain the height of a point by ordinary stadia methods, the rod reading, multiplied by its constant, must be multiplied by one-half of the sine of twice the angle of elevation; or tables or diagrams must be employed for this end. With the Hammer-Fennel instrument the stadia wires are made to separate from one another, automatically, as the vertical angle increases, and the rod reading, multiplied by 20, gives the difference of height directly, with all needed precision.

Prof. Hammer's aim was to accomplish the adjustment of the wire intervals automatically; this he has done most ingeniously by an optical device, with curved cross wires drawn exactly to the requisite form and then photographically reduced to the size needed, which is one-twentieth of that of the original drawing.

Fig. 1 shows the field of view seen at the eye-piece of the telescope. To the left, only the curved reading wires are seen; to the right can be seen the distant rod. G, is a circular arc always appearing tangent to the horizontal wire N N. The zero wire, N N, is placed at a considerable distance from the optical axis of the telescope, as shown, so that the scope of the diagram for vertical readings may be as large as possible.

Fig. 2.

E E, is the line of horizontal distances; it is a curve slowly approaching G. H H, is the line of vertical distances, a curve which rapidly departs from G. Rod readings are taken at the points where these curved lines seem to impinge upon the rod. The rod interval between G and E E, multiplied by 100, gives the horizontal distance of the rod; the rod interval between G and H H, multiplied by twenty, gives the difference of elevation. In the diagram:

Horizontal distance = $100 \times 0.141 = 14.1$ meters
Vertical difference of height = $+20 \times 0.085 = +1.70$ meters

The + signs shown under H H, appear numerously and indicate an angle of elevation. With an angle of depression the — sign appears, as the other half of the diagram comes into view.

Fig. 2 shows the entire diagram, somewhat magnified.

As actually used the radius of the circular arc G, of Fig. 1, is 30 millimeters. This diagram is firmly attached to one of the standards, with its plane in a vertical position. As the telescope is raised or lowered different portions of the diagram come into view at the eye-piece, by reflections from suitably placed prisms, as shown in the sectional drawings. The diagram admits of vertical angles of + or — 30°, which are assumed to be practically useful limits; however, the diagram can easily be extended for greater angles if a larger multiplier than 20 is assumed in the original construction of the diagram. With an increase of scope in the vertical element, by increasing the multiplier, the precision of the corresponding diagram would be diminished. The multiplier 20 is taken on account of the ease of multiplying by this number, 25 having been tried on the instruments of earlier construction. It very rarely happens in practice that angles of elevation or depression greater than 30° are found.

The line drawings of the instrument, in elevation and various sections, show the essential features of construction without further detailed description. The reproduction of the photograph shows the instrument as it appears in its most recent form. Although the reading of the horizontal limb, by verniers or otherwise, has nothing to do with the essential and novel features of the tachymeter, rapidity and certainty of reading of the horizontal angle are to be sought and are here obtained by the adoption of Fennel's "Estimating Microscope." Fig. 3 shows the field of view of one of these microscopes, the fixed wire indicating the reading of 124° 36'. Each degree is clearly

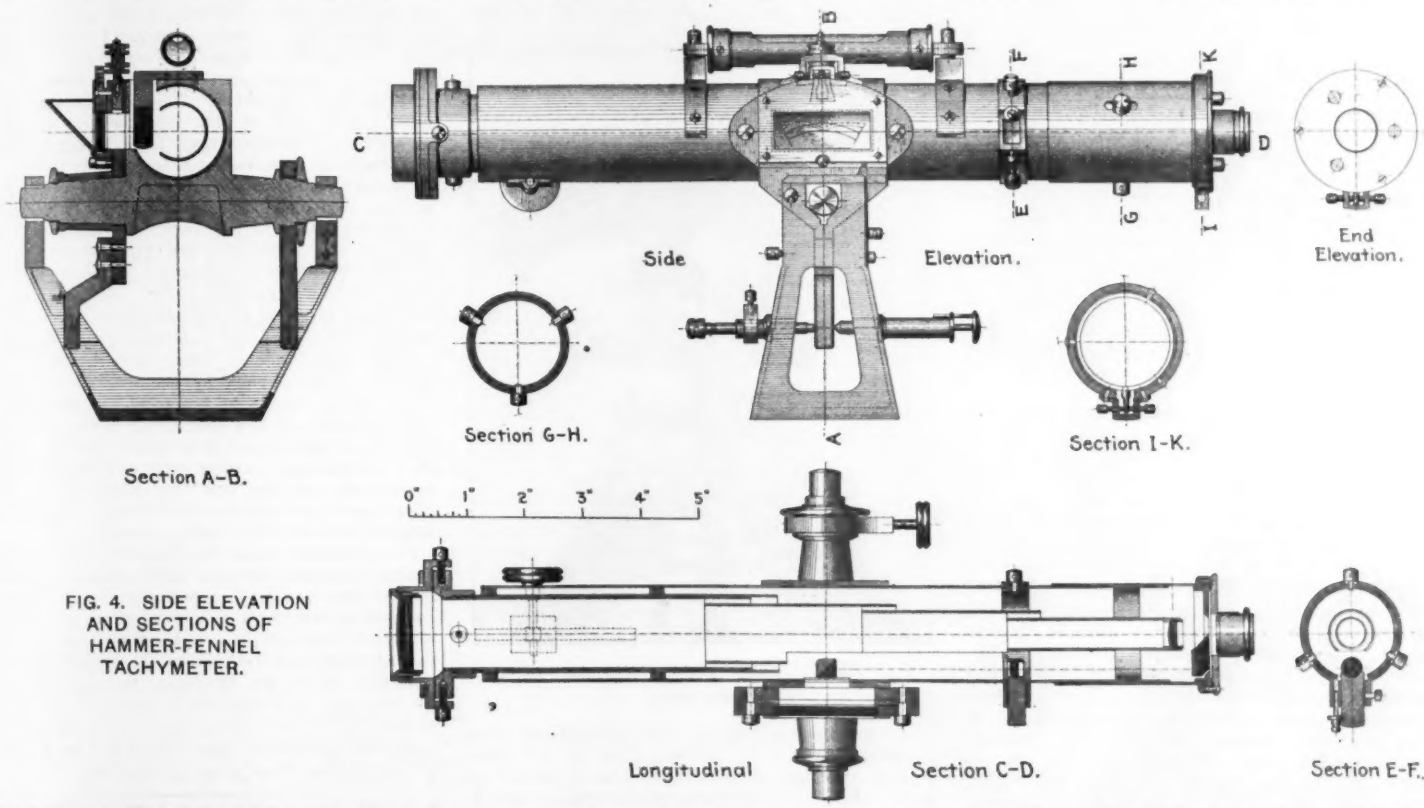

FIG. 4. SIDE ELEVATION AND SECTIONS OF HAMMER-FENNEL TACHYMETER.

numbered, while good illumination is secured by the vertical reflector tubes.

The Hammer-Fennel instrument has been patented for two years, but as yet very few have been put on the market by the maker. With the present improvements in form and with the means for making accurate and rigid adjustments a larger use of the instrument and better means of judging of its efficiency may soon be expected.

Fig. 3. Field of View of Microscope of Tachymeter.

Prof. Hammer has made numerous trials with the somewhat rudimentary instruments. His results indicate probable uncertainties of only about one meter in the horizontal distances, up to 300 meters, and errors of height of not more than 10 to 15 centimeters, while the adjustments are said to be easily effected and to be well maintained.

ADVICE TO YOUNG ENGINEERS.

A late lecture delivered by Dr. Alexander B. W. Kennedy, F.R.S., to the students of the City and Guilds Central Technical College, of London, had for its subject, "The Consulting Engineer," and as it is full of good advice to the young engineer anywhere its chief points are here noted. The matter applies to the engineer who has completed his academic work and has had sufficient practical training to undertake work upon his own responsibility; to plan a general engineering scheme, and, above all, to settle the question of merit in the several possible plans as contrasted with the financial cost to his employers. In fact, the most essential part of the consulting engineer's work is the consideration of what a certain thing will cost and whether it will pay to carry it out. A great many conditions influence this question, and here experience in other similar public works, sound judgment and a close study of contrasting details of actual practice can alone produce the best results.

The immediate cost of any plan laid down can be readily estimated; but it is a more difficult question to decide whether certain variations or changes in this plan—which cost money—will or will not be profitable if carried out. There are usually several ways of accomplishing the same end, and the one costing the most money may be the "better" way, by saving fuel, or in some other economic conditions. The problem must be studied from the financial as well as the engineering point of view, and the engineer's first duty to his employer is to answer the question: Will this enterprise pay for the outlay proposed? For example—says Dr. Kennedy—in the case of a power house, condensing engines may save about 15% of your fuel, and condensation is therefore "better" as the engineer sees it. But in a case in point, the actual cost of this condensation plant was $150,000; and if that extra outlay was to entail an annual charge of $7,500, the question to be settled is, whether the saving in fuel is, or is not, worth that amount.

This same rule of conduct applies especially to transmission plants, to the utilization of water power and other schemes of similar magnitude. In such schemes the actual capital expended is usually very large, and it is very nearly independent of the hours per day in which the power can be utilized; the capital charges are almost the same whether the plant is operated six hours per day or continuously day and night. As a rule, the success of any great water power scheme depends upon the ability to utilize the energy generated through the whole 24 hours, and to distribute the capital charges accordingly.

With his scheme fully worked out, and its financial standing decided upon, the next duty of the engineer is the preparation of his specifications; and this is a matter of no small difficulty. The first requisite of a specification is that it should be perfectly clear and perfectly complete, so that the contractor may know exactly what he is proposing to do and what is expected of him. Without this clearness and completeness there is trouble ahead for all parties concerned. But while complete, the specifications must not be so detailed in the sizes of every nut and bolt that you take responsibility out of the manufacturer's hands and render it difficult for him to use his own methods and patterns. The usual result of such detail is enhanced cost for work that is no better than would otherwise have been furnished. On the other hand, if the engineer proposes something absolutely new, it is eminently desirable that he work out in detail some way of doing it and include this in his specifications; otherwise he may be met with the statement that it cannot be done, and was never done before. It is only fair to the contractor to indicate in detail at least one way of accomplishing it. To issue a sort of open specification which tells practically nothing is to make a damaging admission of the ignorance of the engineer, and it practically puts him in the power of the contractor throughout the construction of the work.

Another point made by Dr. Kennedy relates to a too frequent method of manufacturers and other employers of labor, and that is that if you positively intend that either A, B or C among a number of prospective bidders shall perform the work, say so at once, and do not give other contractors the labor of preparing tenders which you know beforehand will not be considered. If you expect to receive tenders for things which can be made

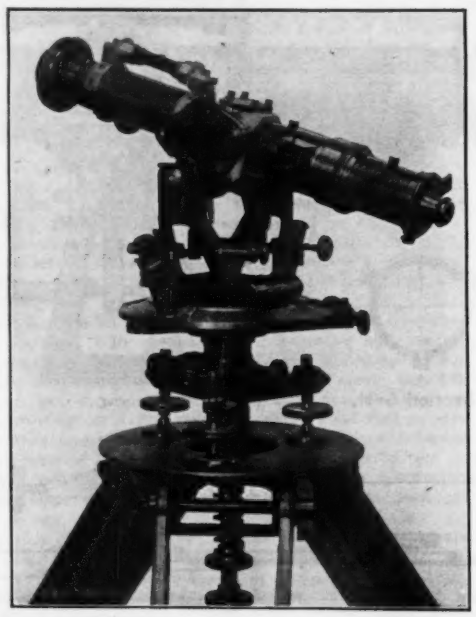
Fig. 5. Perspective View of Hammer-Fennel Tachymeter.

in different ways, but are equally good, let your specifications be so worded that all of these makers can fairly undertake what is asked of them. But as manufacturer's evidence that a thing cannot be done is purely negative evidence, and merely means that he does not know how to do it, his evidence is only final when he knows that it can be done, because he has done it himself.

Another important point about a specification is the common demand in this document that the contractor "guarantee" something. This demand sounds well, but it too often means nothing at all. A guarantee, to be of any use to the engineer or to his employer, must be accompanied by some conditions as to its enforcement, and by information as to the experience upon which the guarantee is based.

In regard to the arbitration clause which every specification contains, Dr. Kennedy advises against the engineer being the sole arbitrator. The engineer naturally believes himself right in any dispute and stands up for himself; this being the case, it is clearly unfair that he should also be the final judge. It is much better to say that on certain technical points the engineer's decision is absolutely final; but as to the interpretation of clauses or other general questions, an outside arbitrator should be fixed upon. In his own practice Dr. Kennedy uses the formula—"The arbitrator shall be nominated by the President of the Institution of Civil Engineers"; this insures the appointment of a competent and impartial man.

The selection of the most acceptable among the tenders submitted is one of the most difficult, as it is one of the most important duties of the engineer. The only general guide is that, supposing the tender to have been entirely open, advise the acceptance of the lowest tender among those that are absolutely satisfactory. This means the previous rejection of the tenders of those who have never done similar work and are ignorant of what would be required of them, and those who are incompetent and would cause loss to your employers by reason of inexperience. In the end every set of tenders must be considered on its own merits.

With plans complete and work let, the next thing is to see that the work is carried out in accordance with the specifications; and unless the latter meet the requirements of clearness and completeness your troubles now begin. But with a good set of specifications and a sound contractor matters will go smoothly. The engineer, however, should always remember that he is really an arbitrator between his clients and the contractors. He has first to see that his employers get what is specified; and, on the other hand, he has to see that the contractors are fairly dealt with, and it is not easy to hold an even hand in these matters. In cases of failure to meet time requirements the engineer must not say at once that no allowance will be made. The weather may have been bad enough to stop the work, or the work of another contractor may have interfered with his progress. The engineer is really a judge, and he should consider fairly whether the contractor, in view of the terms of his contract and the facts of the case, is or is not entitled to an allowance. Says Dr. Kennedy: Do not put yourself in the attitude of always demanding your pound of flesh, even if you are entitled to it. Absolute compliance with specified conditions must sometimes be insisted upon, but the engineer's position for enforcing compliance is much stronger if he has honestly tried to look on the matter from both sides before making up his mind. In cases of defective details, if this defect is a source of weakness or danger, reject it at once; but, as in the case of castings, a defect may sometimes be only superficial, and its rejection would cause your client much inconvenience by delay. The guiding rule in such cases is common sense.

The lecturer closed his remarks by warning young engineers against undertaking too much before their practical experience had been sufficient to enable them to act intelligently; and he especially warned them against putting any patent of their own into their specifications, or of "touting" for work. In regard to the latter point Dr. Kennedy says that every one who has tried it is sorry for it afterwards; it is better not to do in your own profession what would not be tolerated in any of the other great professions.

MASONRY AND STEEL HEAD-GATE OF THE GRAND VALLEY IRRIGATION CANAL, COLORADO.

By Clarence T. Johnston.*

The head-gate of the Grand Valley Canal, Colorado, is located on the right bank of the Grand River, about twelve miles east of Grand Junction. For a number of years after the construction of the canal, a temporary wooden head-gate served the purpose of a regulator of the volume of water flowing into it, but, owing to the direction of the current of the river during the flood season, the structure threatened to go out on several occasions, and it would have been washed away during the high water period of 1900 if it had not been heavily loaded with rock. During September of that year, the Grand Valley Irrigation Co. determined upon the installation of a head-gate which could be operated with greater ease, and which would withstand high water. The material through which the canal runs near its head is very porous; the bed of the canal for some distance below the head-gate being covered with large cobblestones. A few hundred feet north of the canal, a ledge of shale shows on the surface, and it was suggested that the canal line be changed so that it might reach the river in this material. Owing to the un-

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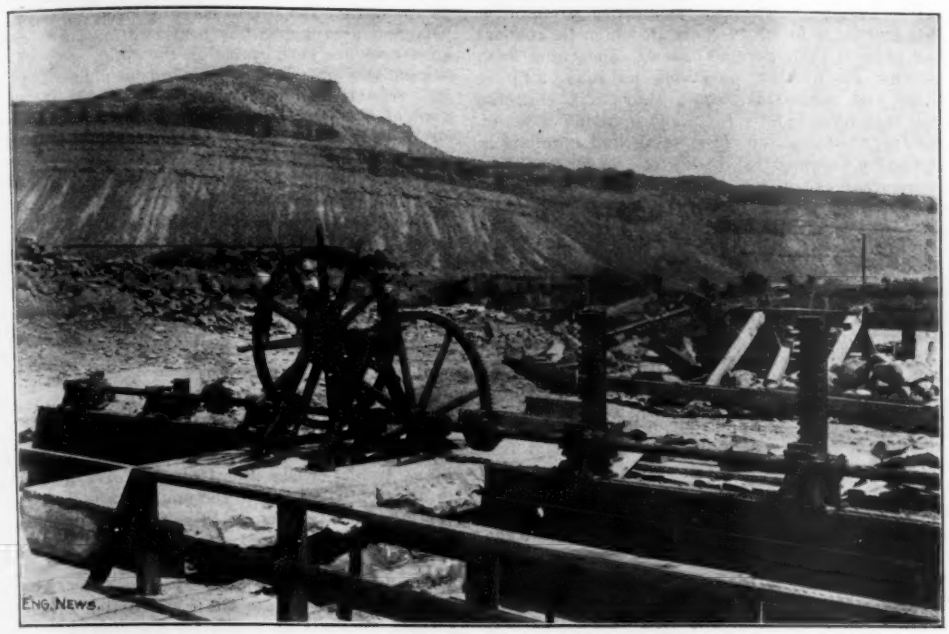

FIG. 1. VIEW OF MASONRY AND STEEL HEAD-GATE, GRAND VALLEY IRRIGATION CANAL, COLORADO.

certainty of the depth of the shale, and its quality to resist erosion, it was finally decided to install the new head-gate just below the existing wooden structure.

The head-gate, Figs. 1 and 2, was planned so as to permit of a larger discharge of water than the canal now carries, as it is the intention of the company to enlarge the channel at a later date. Seven gates were, therefore, provided; each 5½ ft. in width. The gates proper are 6 ft. high and 6 ft. 5½ ins. wide. Above the gates a breast-plate has been provided, which has been designed to withstand the pressure of 16 ft. of water, and the impact of partially or wholly submerged logs, weighing five tons and moving at a velocity of 3 ft. per sec. The gates are raised by a capstan, on the shaft of which is a pinion 5¼ ins. in diameter. This bites into the teeth of a wheel 65½ i s. in diameter, which is keyed to a 3-in. steel shaft which runs the entire length of the beams above the gates. Opposite the stem of each gate, a pinion has been provided which bites into the teeth of a rack on the stem. The pinions can be driven along the shaft so that any or all gates may be operated at one time. In practice the lifting apparatus has proved entirely satisfactory. One man can easily operate the gates, regardless of the depth of water above them.

Brass bearing faces 2½ ins. in width have been riveted to the gates, and to the posts upon which they slide. Guides have also been furnished which prevent the gates from swinging away from the posts in event of pressure of water from the down-stream side of the structure or a westerly wind. The posts have been made sufficiently heavy so that no inclined struts are necessary. These generally give trouble where driftwood is plentiful during high water. Weeds and other drift collect on such a piece, which not only interferes with the operation of the gates, but threatens to loosen the lower end of the strut, which is generally fastened into the concrete floor. The steelwork was painted before being shipped and it has been repainted twice since the structure was completed. All of the lifting apparatus and other gearing have been housed and in other ways protected from the weather.

A pier runs parallel with the side walls, dividing the head-gate into sections of three and four gates, respectively. The lifting apparatus is located on this pier. The masonry work is supported on a concrete foundation 4 ft. thick, which lies immediately above the cobblestone formation. The floor of the head-gate is of concrete, 3 ft. in thickness. The concrete is composed of 1 part Portland cement, 3 parts of sand, and 5 parts of broken stone. The side walls and wing walls are 6 ft. wide at the base and 4 ft. wide at the top. The middle pier is 6 ft. wide at both bottom and top. The stone used in the masonry work is from the Frying Pan quarries, located some 60 miles above the head-gate, on the Grand River. It is a very hard dark red sandstone of fine texture.

The entire cost of the head-gate was $13,500; of this the steel work cost but $3,500. A bridge is supported by the side walls and pier above referred to.

AN ELECTRIC MONO-RAIL RAILWAY between Manchester and Liverpool, England, was authorized by the British Parliament in 1900, but it was required that the plans for the structure and the electrical equipment should be approved by the Board of Trade. The Manchester & Liverpool Express Ry. Co. is now asking for subscriptions to its capital of $10,500,000. The system of construction is that invented several years ago by Mr. F. B. Behr, and as yet applied only to some small local steam lines in Ireland and Belgium. It is practically a three-rail system, the cars straddling a superstructure consisting of A-frames with the main track rail laid upon their tops, and a guide rail along each side. The cars are made with longitudinal seats, the passengers sitting with their backs to the structure. The special features of the proposed line are the electrical machinery and the high speed of the trains. The length of the line will be 34½ miles, and the trip is intended to be made in 20 minutes, without any intermediate stops, while the numerous steam railway trains between the two cities take from 40 to 45 minutes. It is announced that trains will be run on 10-minute intervals at a speed of 110 miles per hour. Under these conditions the brake and signal equipment will of course be a matter of the highest importance. There will be no switches on the line. The Board of Trade has now sanctioned the construction of the road, after considering the detail plans submitted. The engineers are Mr. R. Elliott Cooper, M. Inst. C. E., and Mr. F. B. Behr, while Lord Kelvin and Sir William Preece are consulting engineers for the electrical work.

THE ORE STEAMER "GRANGESBERG" is peculiar in being fitted with apparatus for discharging its cargo, so that it does not rely upon discharging plant at the docks. This is done for the reason that the cargo is discharged in open water into barges. The vessel was built by Doxford & Sons, of Sunderland, England, for the Baltic service of W. H. Muller & Co., of Rotterdam, Holland. The steamer is 462 ft. long, 62 ft. beam and 29 ft. deep, with a draft of 22½ ft. The hold is loaded by six spouts on the dock, delivering the ore into six hatchways, on each side of the central longitudinal bulkhead. Each hatchway is fitted with a deflector like an inverted V, so that the ore forms 24 heaps or piles within the hold. Along the deck are seven pairs of short masts, connected by transverse beams, and each mast has two derrick arms for handling the buckets, while a hoisting engine is provided for each mast. Four of the masts are arranged to carry sails if necessary. The hull is of the turret type, the deck being very narrow, and the sides then curving out in concave form to the full width of beam. In this way the hold can be loaded practically full, with very little lost space at the corners, which space must be paid for according to the measurement of the vessel. The "Grangesberg" has a triple-expansion engine of 2,400 HP., placed at the stern, as in the ore vessels of the Great Lakes. The steamer has discharged 10,000 tons in 30 hours.

ELECTRIC GARBAGE CARS have been put in service at Savannah, Ga., to convey garbage from the city to the dumping point and to the crematory which is to be built. The cars have closely covered bodies of 15 tons' capacity, and are dumped by means of a lever, no shoveling being required. The garbage will be carried to the County Farm, where all tin cans and other junk will be picked out and the refuse buried. The city will pay the Savannah Electric Ry. Co. $20 a day for hauling 75 tons, and $4 per car for all in excess of that amount.

THE PUBLIC CONVENIENCE STATION at San Francisco, noted in our issue of July 23, has proved its practical value by the high record of attendance. During the first week the number of men using it averaged about 1,000 per day; the second week it was 7,900, or over 1,100 per day. Since then the attendance has varied from 1,000 to 1,300 per day, the station being open from 10 a. m. to 6 p. m. The station has two sections, for men and women, but no record was kept of the number of women. Besides the urinals and water closets, there are wash basins, with running water, towels and soap.

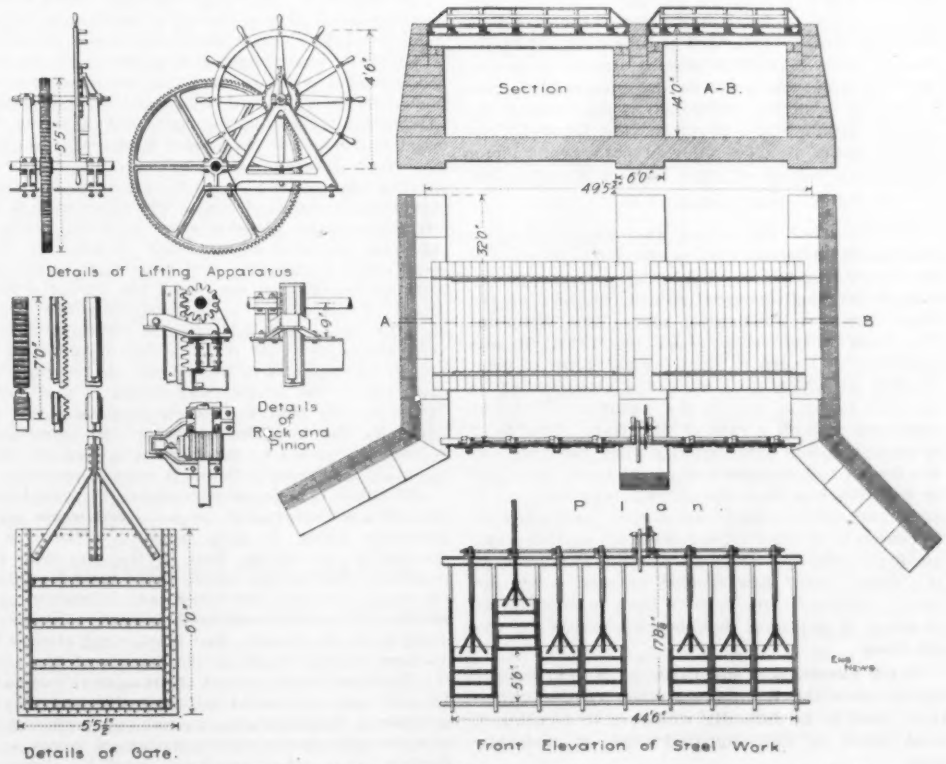

FIG. 2. DETAILS OF MASONRY AND STEEL HEAD-GATE FOR IRRIGATION CANAL.

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ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.

The article on anchor ice, as related to water-works intakes, published elsewhere in this issue, is notable both for the information on a special subject which it contains and as a carefully prepared review of local experience through a long series of years, correlated with all other like information available. If similar studies of anchor ice were made and published by engineers in other localities, doubtless additional light would be thrown upon a vexed problem. Mr. Hubbell's example might also be followed with profit along scores or hundreds of other lines of investigation.

The reported closing of the water filtration plant at Wilmington, Del., ought not to be allowed to deceive any one as to the efficiency of well-designed and well-operated filters, whether of the slow sand or mechanical type. The Wilmington filter stood in a class by itself. It was described at length in Engineering News of Sept. 8, 1898, at which time we called attention to its peculiar features, and to the unsupported claims made for so high a rate of filtration. Outside of Wilmington, and aside from parties interested in the design and construction of the plant, the filter in question has been universally considered as a huge and unwarranted experiment, conducted at the expense of the city, and without anything like adequate returns. It is no wonder, if true, that the water board has decided to shut down the plant. Contradictory reports have been made as to what, if anything, will be substituted for the old filter.

Water purification has made such notable advances since the Wilmington plant was built that there need be no difficulty whatever in securing a good plant, of well-approved type, at moderate cost.

The purpose of the correspondence columns of this journal is to afford space in which its readers can express their personal views concerning such current engineering questions as may interest them and respecting which they may conceive that they have to offer facts and opinions of value. No responsibility for these facts and opinions is or can be assumed by the editors, beyond that of seeing that every correspondent practices the ordinary courtesies of controversial discussion; that personalities are eliminated, and that the time of the paper's readers is not consumed to the exclusion of more valuable matter by trivial subjects or long-drawn-out disputes. To "edit" these letters beyond this point, and particularly to select or to trim them to suit the opinions of the editors, would result only in dispossessing them of any value which they may have as individual expressions of opinion.

In the discussion which has been carried on in our correspondence columns during the last few weeks concerning the relative advantages of eye-bar chains and wire cables for the new Manhattan Bridge at New York city, the impression has gained ground with some of our readers that the preponderence of letters in favor of wire cables reflects the editorial opinion of this journal. We wish to correct this impression. The editors of Engineering News have not supported either side of this controversy; they have not even expressed any opinion as to the relative merits of chain and wire cables. The only thing they have done is to suggest that competitive bids for a chain cable and a wire cable bridge be asked in order to settle the question of relative cost. It may be, as has been claimed, that this suggestion is impracticable, but it certainly is not an assumption that either type of cable construction is the preferable or the cheaper one. It has happened that the advocates of wire cables have been more numerous and vigorous among those who have written us concerning the Manhattan Bridge designs than have the advocates of chain cables. Doubtless there is a more even balance of opinion among engineers than this fact indicates, and we trust that those who believe in the superiority of eye-bar cables will utilize our space to justify the faith that is in them.

To what extent are sand-boxes used in American practice for supporting falsework or arch centering, and what has been the experience with them? Two instances have recently come to our knowledge where sand-boxes, used in the supports of arch centers, failed to behave as they were intended. One case was the erection of a concrete-steel arch bridge by a well-known American contractor; sand-boxes were used under the supports of the centering to permit of easy lowering, and it was supposed that the sand in them, being entirely confined, was quite incompressible. As the load came on the centering, however, the sand in the boxes compressed sufficiently to crack the fresh concrete of the arch. This experience caused the contractor to declare that he would never again use sand-boxes. The other case is the erection of the concrete-steel arch at Laibach, Austria, described in our issue of July 16. The sand-boxes under the centering had been filled with carefully-dried fine sand, but during a flood the river rose above the level of the supports and wet the sand. When it came to striking the centers, the sand would not flow out of the holes in the boxes, but had to be scraped out, so that the lowering of the centers was irregular and jerky. While in this instance the structure was not injured by the irregular lowering, the same good fortune might not be experienced in another similar case, especially if the arch were of masonry.

Are these two practical failures of sand-boxes exceptional experiences, or are sand-boxes quite generally liable to give trouble?. There is a possibility, of course, that in the one case the contractor did not use clean, sharp sand for filling the boxes, while in the other case, certainly, care should have been exercised to keep the water away from the boxes. But it may not always be an easy matter to get fresh, clean and fine sand for the boxes, or to protect them against moisture. In any case, it would be desirable to know whether a certain grade of sand and perfect dryness are essential to success with sand-boxes, and, further, what other conditions must be observed in the design and use of these devices. What mechanical arrangement is best, for instance; what pressures are permissible on the sand, etc.; where should the opening for the sand be placed to give smooth action in lowering; should it be in the bottom of the box, or in the side, near the bottom, or some distance above the bottom; should the bottom of the box be flat, conical or sloping?

We are under the impression that but little use has been made of sand-boxes in American practice. For small arches nothing better than wedges can be required, but for large arches it is essential that the centering be lowered gradually and uniformly over the entire span, and either screw-jacks or sand-boxes must be used. The simplicity and convenience of the latter speaks strongly in their favor, provided they are reliable.

A BRIEF ACCOUNT OF RECENT LARGE TUNNEL WORKS.

In the initiation and successful prosecution of great tunnel works the United States must, we think, yield the palm to the engineers of continental Europe. In fact, it is somewhat astounding to the American engineer to observe the nonchalance with which European railways of no great pretensions, judging by American standards, will contemplate the construction of tunnel in such amounts as would try the courage of any but the giants among American railways. It is true, of course, that the Alpine railway builder is compelled to tunnel if he is to build railway at all, but this circumstance does not wholly explain the difference alluded to above. Perhaps the fact that the European mind does not take kindly to "temporary expedients" for establishing railway communication is a partial explanation. The American engineer, confronted with the problem of the Simplon Pass, would have been likely to have built a switchback over the mountain to carry traffic until he had husbanded sufficient resources to excavate a tunnel, and having once built this temporary line, he would have exacted the last degree of usefulness from it before resorting to a tunnel line. The European engineers actually did the opposite thing. They waited until the conditions warranted a tunnel line before attempting to establish communication by railway across the Simplon.

To return to the first thought, it is probably realized by only a few American engineers how extensively the building of tunnels of great length and cost is now being prosecuted in Europe. The Arlberg, the St. Gothard and the Mont Cenis tunnels are familiar works to every engineer conversant with the history of tunnel building; they are the lights of the first magnitude in the firmament of the tunnel builder. By name at least the Simplon Tunnel is quite as well known, and in order to lay the details of this great work before our readers we begin in this issue a series of three fully illustrated articles relating to their character and purpose. Were any one of these four great tunnels the only representative of long tunnels afforded by Europe, it would outrank any work of the kind accomplished in America, and several of these American works have been notable examples of the tunnel builders' skill and courage. Europe's claim to precedence in tunnel building does not, however, rest alone on a single one of the tunnels named, or even upon all four of them. There are in progress, or recently completed, a round half-dozen of Alpine tunnels which rank well up toward the magnitude of the masterpieces already existing. It is our purpose here to refer briefly to these less-known structures in order that the reader who follows through the present and succeeding articles on the Simplon Tunnel may be able to corelate that work with other existing and contemplated Alpine tunnels and with the few great examples of American mountain tunnels.

The Simplon Tunnel, when completed, will be the fourth of the great Alpine tunnels, its three predecessors being, as already noted, the Arlberg, the St. Gothard and the Mont Cenis. First, as to length, it will be 12.4 miles long as compared to the 9.75 miles of the St. Gothard, the 7.5 miles of the Mont Cenis, and the 6.25 miles of the Arlberg. None of its predecessor, therefore, come within

2½ miles of being as long from portal to portal as the Simplon. As an American competitor we have only the Hoosac Tunnel with its length of 4.75 miles. In respect to elevation the Simplon Tunnel possesses a far more favorable line than any of its three predecessors; its rails attain an altitude of only 2,314 ft. as compared with the altitudes of 4,248 ft. at Mont Cenis, 4,300 ft. at Arlberg and 3,788 ft. at St. Gothard. It is this low elevation of its line, of course, that accounts for the greater length of the Simplon Tunnel as compared with the others.

No comparison in detail that would be of much value can be readily made between the design and construction of the Simplon Tunnel and that of the tunnels at Arlberg, Mont Cenis and St. Gothard. The mere fact of the advance made in the mechanical facilities available to the engineer which has taken place since the most recent of these predecessors of the Simplon Tunnel was built would alone render abortive an attempted comparison. In fact, if we take into account this progess in the means at hand for the rapid and economical prosecution of work the much recounted difficulties of the Simplon work by no means overshadow those encountered in the Alpine tunnels previously constructed. This we think is particularly true when the comparison is made with the St. Gothard work. There at least the conditions due to subterranean heat, to the inflow of water and to treacherous material were little if anything less severe than they have been at the Simplon. For meeting these conditions and overcoming them without the appalling loss of life and health among the workmen which signalized the St. Gothard work, however, the Simplon Tunnel builders deserve all credit. They had at hand it is true greater facilities for meeting this difficulty, but nevertheless praise is due them for having taken advantage of their opportunities under conditions which might have excused such oversight.

In dealing with the large volumes of water encountered the builders of the Simplon Tunnel have had a powerful aid as compared with the builders of the St. Gothard. in their plan of twin tunnels. The connection of the main tunnel work every few hundred feet with the large advance drift for the second tunnel gave a service gallery of the utmost value not only for the ordinary requirements of the work, but for meeting the abnormal conditions which ultimately developed. So much impressed have the Simplon engineers been by their experience with this supplementary thoroughfare that they strongly advise the twin tunnel plan of construction for any long Alpine tunnel, which is equivalent to saying, for any long mountain tunnel. We may reasonably doubt whether this dictum will be accepted off-hand by engineers, but it cannot be disputed that the plan has something to recommend it.

In observing the plant employed in excavating the tunnel, American engineers will be most impressed perhaps by the failure to employ power drills in the work of enlarging the advance heading to full tunnel section. It is plain enough why the heavy and unwieldy rotary drills used in advancing the heading should not be used in making the enlargement, but there seems to be no reason why the light and compact compressed air drill such as is used everywhere in America could not replace hand labor to great advantage. However, we have the statement of the Simplon engineers that air drills were tried and abandoned simply because they could not compete in cost and speed of work with hand drilling. No doubt the cheapness of Italian labor had much to do with this result, and it may be also that the power drill was not given fair conditions for developing its full efficiency. In driving the advance heading the Brandt hydraulic rotary drills have done excellent work, the daily progress being from 17 to 23 ft. of completed heading in hard and compact rock.

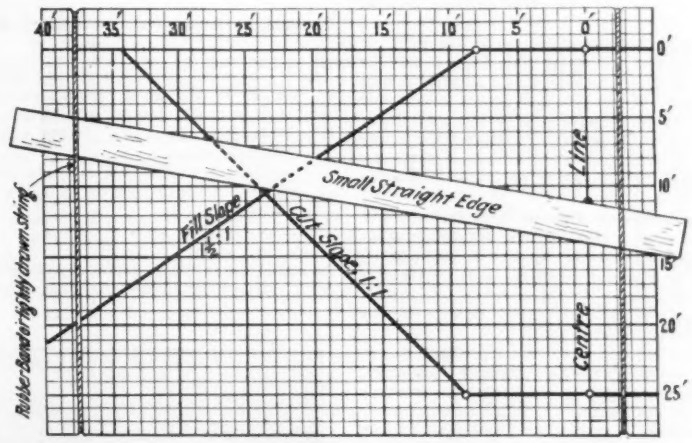
In connection with the hand-drilling work on the Simplon Tunnel it is interesting to note that two of the four railway tunnels being built by the Austrian governement on its new railway extensions are being excavated by hand drilling, while on the other two electric percussion drills are employed. These four tunnels penetrate peaks of the Austrian Alps and are of the following lengths: Bosruck Tunnel, 2.92 miles; Tauern Tunnel, 5.25 miles; Karawanken Tunnel, 4.94 miles, and Wocheiner, 3.93 miles. It will be noted that two of these tunnels exceed in length the Hoosac Tunnel in America. Few details are yet available regarding these Austrian tunnels, but from the short notes which have appeared in the German technical press it may be stated that the work so far has been through generally compact rock, carrying but little water except in the north heading of the Tauren Tunnel, and developing no great rock pressures. From a report of the progress for the month of August we obtain the following figures:

Name.	Heading.	Total length.	Excavation during month.
Bosruck	North	3,228	124.0
"	South	2,096	117.0
Tauern	North	1,643	99.6
"	South	1,411	51.5
Karawanken	North	5,557	352.0
"	South	4,726	335.0
Wocheiner	North	6,239	223.0
"	South	5,261	396.0

The rate of excavation is greatest in the Karawanken Tunnel, and it is in this tunnel that the electric drills are being worked. This tunnel is expected to be completed by the end of 1905. The Tauern Tunnel, which is the longest of the four, is expected to be completed by the end of 1908, which would seem to indicate that it is the intentions to resort to power drills as otherwise the work would be imposible of accomplishment.

The last of the recent Alpine tunnels which we have to record is the Albula Tunnel, now completed, on the Rhaetian Railways in Switzerland. This work was fully described in our issue of Dec. 19, 1901, and need not be further mentioned except to note that its length is 3.66 miles, and it reaches an elevation of 5,982 ft.

While America has no rock tunnel work under way which equals the great Alpine tunnels now in progress in Europe, there is comfort in the knowledge that it leads the world in the magnitude of its tunnel works through soft ground and particularly in its list of subaqueous soft ground tunnels. The Pennsylvania R. R. tunnels under the Hudson and East Rivers; the original Hudson River Tunnel now progressing rapidly to completion; the Rapid Transit Railway tunnel under the East River; the subway tunnel under Boston Harbor, and the score of miles of deep tunnels now being dug under the streets of Chicago are all works of the first magnitude in soft ground tunnelling, and their equals in difficulty of construction and boldness of design are not to be found in any tunnel work eleswhere in progress.



HOME-MADE INSTRUMENT FOR INTERPOLATING CONTOURS.
Alfred S. Burgess, New York City.

LETTERS TO THE EDITOR.

Another Graphical Method of Setting Slope Stakes.

Sir: Referring to the article on a "Graphical Method of setting Slope Stakes," by Mr. J. M. Rudiger in your issue of July 30, I wish to say that I've used that method with modification for some time and find it perfectly satisfactory, and it is of special advantage to a man who is setting slope stakes for the first time, as the whole operation is clearly before him and he won't become confused as he would if he only had a mental picture of the operation.

Mr. Rudiger says: "There have been other ways devised, and the following, while *not so quick* as some others, is so simple and effective that it is submitted in the belief that if tried it will help to turn work into mere play." Now I think by using the diagram as I do without the trouble of stretching the silk cord and sticking pins it will be found as quick as any method yet devised—at least I have seen a man, who, without previous experience in setting slope stakes, stake out as much as an old hand who was using the ordinary method. The explanation for Mr. Rudiger's diagram will answer for mine with the exception that, instead of sticking the pins and stretching the string, I merely slide the small straight edge under the rubber bands or string till I have it set for the proper cut or fill for the given station. I then slide the other end of the straight edge till it is thought to be parallel to the transverse slope of the ground at the station. It is readily seen that this can be done very rapidly; in fact, when the ground is not too irregular it can be set while walking between stations. With a little practice a person can strike it "close enough" the first time a good share of the time. If the first estimate is a little off it is corrected the same as for Mr. Rudiger's diagram. The arrangement is made by drawing lines representing cut and fill, slopes, etc., on cross-section paper, as shown in sketch, and pasting this sheet onto a piece of strawboard, to keep it straight. I find that a strip cut from a celluloid triangle makes a good straight edge. The whole diagram need not be any larger than an ordinary transit book unless the work is to be done very accurately and a larger scale is required.

Respectfully, Alfred S. Burgess.

2092 Bathgate Ave., New York City, Aug. 3, 1903.

Engineers' Reports and Chain Cables for Large Suspension Bridges.

Sir: The letter of Mr. Geo. W. Colles, in your issue of July 23, seems to be quite unnecessarily severe in its criticism of the engineers who made the report on the Manhattan Bridge. If anything, brevity and conciseness in engineering reports are most desirable qualities. Mayor Low was aware either personally or by competent advice of the qualifications of the men chosen by him and a display of learning on their part would have been both unnecessary and in bad taste.

As to the matter of the criticism, the writer thinks that the question of painting a large assemblage of eye-bars and the question of the appearance of a chain bridge deserve consideration. While it would be rash to jump at the conclusion that because the comparatively small chain bridges built so far present a poor appearance, therefore in a bridge of great magnitude the same effect will follow, it might be well to study this question of appearance very carefully before deciding.

It would be interesting to know what sizes of eye-bars it is proposed to use and how many are to be packed at one joint. With an extremely long pin it seems that the difficulty of getting all the bars strung on it of exactly the same length would be serious, and the chance of some bars consequently getting more than their proper share greater than in an ordinary bridge, while at the same time the bars are stressed much closer to their limit than in the latter case. If, in order to avoid unwieldy connections, unusually large sections are used, other difficulties arise. It has been shown by full-size tests on large eye-bars that they cannot be judged very closely by the results obtained from small test pieces of the same material. Their behavior under test is somewhat erratic and several reasons can be given for this. In the first place the material does not receive the same proportionate amount of work in the

rolls that small bars would, and secondly the structure of the material in the head must be greatly affected by the upsetting given to it, which alteration of structure is not always removed by annealing, since the difficulty of a uniform heat in the annealing process increases with the size of bar. The report states that nickel steel bars were made and tested, but it does not give particulars as to sizes and other conditions. The writer believes that the points raised would be worth a great deal of thought and experimenting, and that engineers having had charge of tests of large bars should be called on for their opinion. If it should prove necessary in order to settle this question (and the writer can see no other way out of it) to build a special plant to manufacture and test full-size bars of the dimensions required, the large expense involved would be justified, but might throw the balance of cost the other way. If the writer has gone too far in his expression of doubt on this point, he would feel obliged to any one who would give his reasons in full for an opinion differing from his. Important and interesting facts would undoubtedly be brought out by a full discussion. Yours very truly,

Henry Szlapka, Consulting Engineer.

Narberth, Pa., July 28, 1903.

The Seventh St. Chain Suspension Bridge at Pittsburg, Pa.

Sir: Referring to a communication by Mr. Gus C. Henning, published in your issue of July 30, the accompanying view of the Seventh St. Suspension Bridge at Pittsburg, built by me in 1884, may be of interest to your readers.

It will be observed that the stiffening in this bridge is obtained by inserting a triangular web bracing between the top and bottom chains, making of it a suspended arch bridge. A peculiarity of this bridge is that it has no web members or suspenders adjustable in length. All these members were made to the accurate calculated lengths as in an arch bridge. The arches are hinged at the ends, funicular connections, not visible in the view, taking the place of hinges.

The bridge was computed and designed for ordinary street traffic. The succession of two suspended main spans precludes its adaptability for heavy concentrated loads, for which it was not intended, such as heavily loaded trains of cars. They do not occur on this bridge, which carries, however, a heavy street traffic, without restriction on the speed of vehicles.

It is true that a few years after its completion signs of movement were discovered in the Allegheny anchorage. The cause for this was readily ascertained. The anchorage straddled an old deep sewer, which had become leaky. During high water, once or twice a year, the water backed in under great pressure and percolated under the anchorage foundation. It became lubricated and showed signs of movement. As soon as discovered repairs, as advised by me, were made by adding a block of masonry behind and connecting it with the anchor chain in the old anchorage. To do this work effectively four bents of false work were put under each of the two middle spans. The roadway was jacked up to lighten the tension in the chains, while the new and old anchorage were being connected for the purpose of making them work together, very much in the same manner as the weak anchorages of the old Roebling railroad suspension bridge over the Niagara River were reinforced in 1880. The repairs were cleverly carried out without stopping traffic by Mr. H. Laub, Mem. Am. Soc. C. E., formerly connected with my Pittsburg office. The anchorage on the Pittsburg side has never moved a hair's breadth. Since the repairs were made the bridge is in as good a condition as ever before, under a steadily increasing street traffic. No reversal of stress occurs in any part of the chain in the suspended structure.

The design fully justifies the expectations as to rigidity. The chains are apart 1-32 of the span, which would correspond, for instance, to stiffening trusses in the Brooklyn Bridge, about 50 ft. high in place of the present 18 ft. high.

A peculiarity of the design will be noticed in that on the Allegheny side the chains are carried through a truss about 90 ft. long, of the same height as the suspended cable arches. The top and bottom chord in this truss are also composed of eye-bars. Compression occurs sometimes in the end panels of the top chord. There the eye-bars are braced with cast-iron separators.

The statement that the bridge was at any time in danger of collapsing is not true. Mr. Henning's connection with the bridge was simply that of an inspector of the iron work at the bridge shops, where the superstructure for the bridge was manufactured. Of course the accident to the anchorage of the bridge would have happened just the same if there had been wire cables instead of the chain of eye-bars.

The view of the bridge shows in the background the old Sixth St. Suspension Bridge with wire cables, built by John A. Roebling in 1854. General weakness and progressive corrosion of the iron wire cables was the cause of its reconstruction. A heavy truss bridge was built in its place in 1891.

Reference is also made in Mr. Henning's communication to the new Buda Pesth Bridge. It is an eye-bar chain bridge of about 1,000 ft. span, the eye-bars being 10½ ins. wide and 1½ ins. thick. In that bridge there was also trouble with one of the anchorages, namely, that on the Buda side. Near its location hot springs were found. The bottom and sides of the anchorage masonry were provided with a waterproof composition to keep the masonry and iron work of the anchorages dry. Before the bridge was completed a slight movement was discovered in this anchorage. An examination showed that the heat from the hot springs had penetrated to the waterproofing composition, softened it, and in that way had lubricated the base. Here also it was necessary to provide additional anchorage mass to prevent further sliding, and that delayed the opening of the bridge. Mr. Czekelius, the very able engineer of this bridge, may not be a little astonished to learn that all that trouble could have been avoided if he had only used steel wire cables in place of eye-bar chains.

It does not seem to me necessary to reply to the rest of the article which I quoted, except perhaps to suggest that engineers, here and abroad, will wonder how it was possible for the thousands of eye-bar bridges built in the last 80 years not to have collapsed long before this time. If the opinion of Mr. Henning is correct the bridge shops in this country had better close their eye-bar plants forthwith and cease to impose their dangerous structures on an unsuspecting and confiding public.

G. Lindenthal.

New York, N. Y., Aug. 6, 1903.

Rational Formulas for the Strength of Concrete-Steel Beams

Sir: I have read with interest the article in your issue of July 30 by Mr. S. E. Slocum on the calculation of reinforced concrete beams, and in connection with his demonstration beg to raise a question which it seems to me has been overlooked.

In reducing the composite beam to an equivalent area of concrete, the new section is based on the formula

$$p_s = \frac{E_s}{E_c} p_c,$$

E_s and E_c being the moduli of elasticity for steel and concrete, respectively. Now it has been demonstrated in your columns that E_c is twice as great for concrete in compression as in tension, as well as that it is not constant for either one, but varies with the stress. This latter variation may be taken care of with a constant, as Mr. Slocum suggests, but that the great difference in the modulus of elasticity for concrete in compression and in tension could be as easily corrected is not so clear to me.

In the equivalent section the area of concrete below the neutral axis is assumed to take the same stress per square inch as the area above in proportion to its distance from the neutral axis, as is evident from the form of the figure. This cannot be the case, owing to the difference in the moduli of lasticity, and to reduce the whole section to an equivalent homogeneous section based on concrete in compression, the area of concrete in tension would have to be reduced just as that of the steel was increased.

In a deep beam especially, with reinforcement all near the bottom, the effect of this error would be much greater than in the example given, and the difference would be on the side of danger.

If my reasoning on this question is faulty I would greatly appreciate being set right, and would be glad of an answer to the following questions:

(1) Is it possible to find a constant to compensate for the varying values of the modulus of elasticity of concrete?

(2) Can a homogeneous section be deduced equivalent to a composite beam of steel and concrete, taking these varying values into consideration?

(3) In the equivalent section given by Mr. Slocum would not the neutral axis have to pass through the center of gravity of the section, as in any homogeneous beam, and therefore of necessity come below the center line; whereas experiments as well as theoretical deductions show that it is nearly always above the center line?

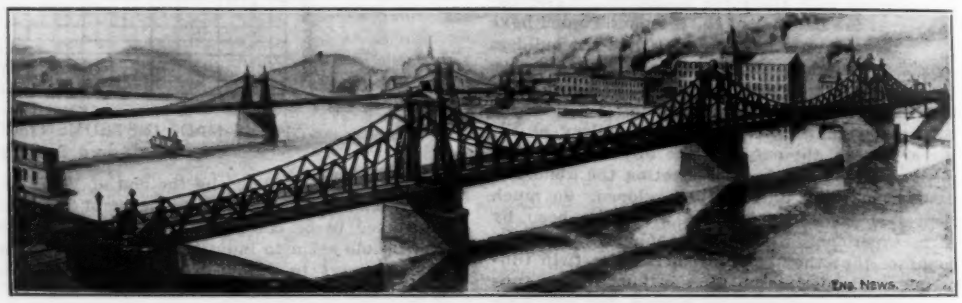
This question is of great interest to me, and any further information on the subject would be greatly appreciated.

Very respectfully yours, Charles C. Hurlbut.

1 Madison Ave., New York City, Aug. 3, 1903.

Sir: In taking exception to some statements in the article of Mr. S. E. Slocum in your issue of July 30, I have no desire to discuss the theory of reinforced concrete in detail. Different analyses are coming upon us thick and fast, especially from Germany, and what is now needed is knowledge of facts, to which the theory must conform, rather than any further mathematical exercises. The writer has been interested in reading this article. However, he fails to recognize the need of Mr. Slocum's array of integrals and quotations of German authorities to establish the very elementary relations of theoretical mechanics which he has presented. His work is a repetition, in a form unfamiliar to most engineers, of the analysis of the simple theory of flexure. He uses J. B. Johnson's convenient method of modification of the actual section of a reinforced concrete beam to an equivalent all-concrete section. The example chosen for discussion of a beam built upon a tee shape, afterwards modified to a strap, which forms the outside lower face of the beam, is beyond the range of practical design. It is a curious turn in Mr. Slocum's procedure, that after his preliminary and logical, but barren, mechanical analysis, he jumps immediately into empiricism by taking the position that the steel must be designed to carry all or nearly all of the tension. Any method of establishing an analysis for this construction which omits the consideration of the tensional forces existing in the concrete, is certainly not a correct description of the facts. I recognize heartily the practical usefulness of such empirical formulas as have been established by Mr. Thacher, but if Mr. Slocum is working to this end, why such mathematical thunder in the prologue?

The writer has advanced an analysis which is built up on the known experimental facts with regard to the nature of the materials entering into this construction.*



SEVENTH STREET SUSPENSION BRIDGE AT PITTSBURG, PA.
Gustav Lindenthal, M. Am. Soc. C. E., Engineer.

(Bridge built in 1884; Pittsburg side span, 165 ft.; two center spans, each 330 ft.; Allegheny side span 165 ft.; truss span over Pittsburg & Western R. R. tracks, 90 ft.; total length, 1,080 ft.; width, 42 ft.; live load, 3,200 lbs. per lin ft., of which 1,200 lbs. is unbalanced traveling load.)

As Mr. Slocum points out, this analysis is for the bending strength only, and needs to be supplemented in some cases, certainly in the example chosen by him, by calculations to determine if there is danger that the adhesion between the cement and steel will be destroyed through the action of horizontal shearing forces between the concrete and the steel. The reason why the writer does not believe that these are important, is that in any true reinforced concrete construction it is not economical to insert a sufficient amount of steel, or bunch the steel at particular points in such a way, that this adhesion may be overcome. It may be remarked that such systems, in which large masses of steel are simply surrounded and protected by concrete, are not, in the writer's opinion, true reinforced concrete construction any more than a rubble wall is a concrete wall. The essential element of such construction is that the reinforcement may be distributed in such a manner as to give increased extensibility to the mortar, with the result that the flexibility of the beam is increased, and that thereby the tensile strength of the steel and the compressional strength of the concrete may be developed before a crack occurs in the mortar under tension. In forms of construction where the reinforcement is concentrated in large masses, these shearing stresses must, no doubt, be closely calculated.

That "the actual failure of beams is due in most cases to the tensile stresses arising from shear" is a statement that needs confirmation. It is not in accord with the

*American Society for Testing Materials, Atlantic City Meeting, 1902.

writer's experience with beams in which an economical amount of metal is inserted. Nor is the failure due to horizontal shear itself. Of course, if one makes the mistake of putting so many bars in the bottom of a beam that there is very little union between the concrete above and below these bars, failure will occur in horizontal shear between the mortar and the metal. Or, to go to the extreme case, if a beam is made with a flat strip of metal covering the bottom of the beam, failure will probably occur in horizontal shear.

In twenty-one stone-concrete beams tested by the writer none failed under horizontal shear.

In twelve gravel-concrete beams tested by the writer, only one of these failed in horizontal shear, and this was a beam that was over-reinforced.

These beams were 8×8 ins. in cross-section, 80 ins. span, reinforced with from 1% to 20% of metal in the tension side. The first indication of failure in these 32 cases was a crack in the tension flange. In some cases, if the experiment be continued beyond the point of first failure, a crack develops in the side of the beam in the plane of the top of the reinforcing bars.

It is significant to the writer that two engineers of ex-

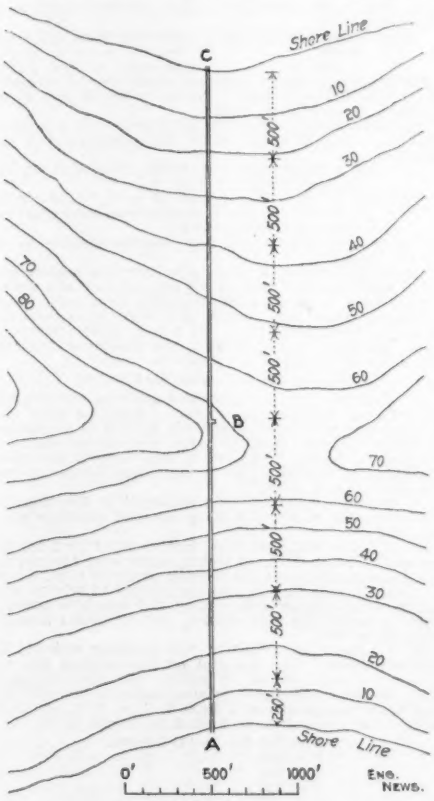


Fig. 1.

tended observation and experience in this construction, namely, Mr. A. L. Johnson and Edwin Thacher, have placed themselves on record in opposition to Captain Sewell, who is quoted by Mr. Slocum. Their observation agrees with the results quoted by the writer.

The writer does not see the necessity of calculating the pure tension, inclined 45° to the horizontal, which exists as the resultant of the vertical and horizontal shears at the neutral axis. The tensile strength of the motor at the bottom face of the beam, where no horizontal shear exists, will be exceeded before the resultant anywhere in the interior of the beam reaches a dangerous value in beams of existing forms.

The statement that,

> For such material as steel, wrought iron and wood it can be easily proved that if a beam of rectangular cross-section and of length greater than its breadth is so designed as to be safe against bending moment, its safety against shear is assured,

is not clear to the writer. If it means that a wooden beam whose span is greater than its depth will not fail in horizontal shear, the statement is certainly wrong.

In conclusion the writer hopes that he has not been too abrupt in wording this letter. It is a good thing that men with theoretical and mathematical ability like Mr. Slocum attack just such problems. But, as a word of caution, he would say that any step in mathematical reasoning should be accompanied by numerical calculations based on existing beams and experimental results. In this manner one's steps will not be led in the wrong direction.

Yours truly,

W. K. Hatt.

Washington, D. C., July 31, 1903.

(In accordance with our customary practice, these communications were submitted to Mr. Slocum for reply, and the reply received is appended below.—Ed.)

Sir: In replying to Prof. Hatt's criticism of my article I would like to state first the standpoint from which my article was written. My chief object was to show as clearly and concisely as possible the exact nature of the internal stresses involved in the theory of beams; calling special attention to certain tensile stresses which are of utmost importance in concrete-steel construction, and upon which little emphasis has as yet been laid. It was also my object to point out that the most powerful method of analysis consists in developing a general theory first of all, and then applying this theory to particular cases by specialization of the quantities involved. If, as Prof. Hatt says, this method is "unfamiliar to most engineers," at least one of my objects in writing the paper is fully attained.

After developing the general theory, it is applied, in my article, to the particular case of a concrete-steel beam. In order to make the paper of practical value it was necessary, in so doing, to assume certain well known properties of both concrete and steel. But it is to be carefully noted that the "empiricism" involved in assuming such constants as the modulus of elasticity of a substance (namely, such constants as are dependent simply on the composition of a substance and not on its dimensions or relative position) is entirely different from that empiricism which consists in deducing working formulas from purely experimental data.

The form of beam chosen for illustration is one which is being used in extensive concrete-steel tests carried on in Cincinnati. As it was designed by practical engineers of wide reputation it can hardly be said to be "beyond the range of practical design," while from a theoretical standpoint it is the most economical use of steel and cement possible. It is not the purpose of the paper, however, to advocate any special form of beam, but to develop a method which, as stated in the paper, is perfectly general and will apply to any form of beam whatever.

As regards Mr. Hurlbut's queries, it is to be noticed that the forces acting on the cross-section of my beam are calculated separately for those portions of the concrete in compression and in tension. If different values of E_c are used for the areas in compression and in tension, it is thus possible to calculate these forces without modifying in any way the nature of the calculation.

As to the variation of the modulus of elasticity with the stress, the law of such variation could best be determined by a series of careful experiments. If this were done, and the modulus E_c found, say as a function of the distance y from the neutral axis, the varying value of E_c could be taken into account by replacing E_c by its functional value in terms of y under the integral signs in the first column, p. 108, of my article. If E_c were a simple function of y, or could be assumed as such with sufficient approximation, it would then be also a simple matter to deduce a homogeneous section equivalent to a composite beam of steel and concrete.

Assuming E_c constant, as in my paper, the neutral axis of the equivalent section must pass through its center of gravity. The fact that experiment shows that this is not always the case, tends to confirm the statement theat E_c varies wih the stress. Respectfully yours,

S. E. Slocum.

University of Cincinnati, Cincinnati, O., Aug. 5, 1903.

EXAMINATION QUESTIONS FOR CANDIDATES FOR THE POSITION OF CIVIL ENGINEER, U. S. NAVY.

The grade of Civil Engineer in the United States Navy is now full, and vacancies which may occur in the future will be filled by promotion from the grade of Assistant Civil Engineer. At present there are no vacancies in the grade of Assistant Civil Engineer. The last Congress, however, passed a law authorizing the appointment of three Assistant Civil Engineers each year until the full number of twelve is reached. Under the provision of this law, there will be three vacancies in the grade on Jan. 1, 1904. An examination will probably take place next November or December, for the purpose of receiving eligibles for appointment immediately after Jan. 1, 1904. A vacancy in the corps will occur as the result of retirement in March, 1904, and should a sufficient number of candidates pass the examination in November or December, it is probable that this vacancy will be filled by appointment from that list of eligibles. As it is likely that some of our readers may wish to take this examination, we have secured from Admiral Mordecai T. Endicott, Chief of Bureau of Yards and Docks, Navy Department, and publish herewith the questions submitted to candidates at the last examination. These same questions will not, of course, be asked in the coming examination, but they may prove helpful to prospective candidates as a general index of the character of the examination to which they will be subjected.

To repeat information which we have already given, Assistant Civil Engineers will enter the corps with the pay of $1,800 per annum, which

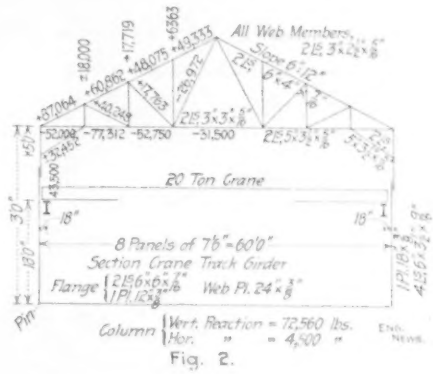


Fig. 2.

at the end of five years will be increased to $2,100. Assistant Civil Engineers, as well as Civil Engineers, are regularly commissioned officers in the U. S. Navy, subject to all the provisions of law relating to such officers, namely retirement on three-quarters pay upon arriving at the age of 62, or if disabled in the line of duty; pension to family in the case of death in the line of duty, etc. It may also be noted that candidates who think of taking the coming examination should have the question of their health and physical soundness definitely determined by a reputable physician before subjecting themselves to the time and expense incident to appearance before the examining board. The medical examination required by the orders of the department is rigorous, and in the last examination numbers of young men were disqualified by the Medical Board. The questions asked at the last examination were as follows:

ENGLISH GRAMMAR AND COMPOSITION.

(1) The papers of the candidates will be marked for this question.

(2) State in not less than 500 words whether in your opinion it should or should not be the policy of the United States to increase the number of its foreign naval stations and why.

(3) Correct, in the body of the sentence the following, where necessary:

(a) Though John, George and myself were there, the sentiment of the meeting were so strongly in opposition against our ideas that we could do nothing for our cause.

(b) The formula for these circulations are so intricate as to render the results extremely liable to inaccuracies.

(c) The indices of these books are objected to on the ground that their inaccuracy and incompleteness renders them almost wholly useless.

(d) Even when given work that they should be used to, neither the blacksmith or his helper were able to show their ability.

(e) They, who so often rail at fortune, are the very ones, who, given the opportunity, never betters their condition.

(f) It has occurred to Henry and myself that, though the data is not complete, we could get the result by interpolation.

(g) It is they who make the most mistakes who consider themselves nearest perfection.

(h) I wish I was able to go but I will not have the time to.

(i) Should either John or I be invited we will have to go.

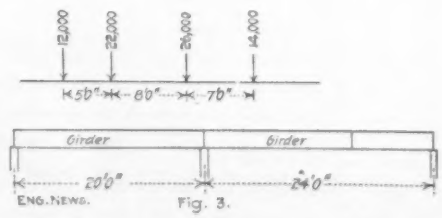


Fig. 3.

(j) Gents will be allowed to smoke on the four rear seats only.

(4) Define the following: Metonymy, allegory, metaphor, dactyl, tautology. Illustrate by examples.

(5) Give the present indicative, present infinitive, past indicative and perfect participle of the following: Were, lost, loosen, bat, bit, bid, crow, went, lean, slink.

ARITHMETIC.

(1) It is desired to use the same panel length in the construction of three buildings whose dimensions are to be as follows: 283 ft. 9 ins. × 50 ft., 132 ft. 5 ins. × 50 ft., and 189 ft. 2 ins. × 50 ft. What is the greatest length that can be adopted?

(2) If eight excavators dig a ditch 4 ft. wide, 10 ft. deep and 200 yds. long in 50 days of 10 hours each, how

many nights of 7 hours each will four excavators require to dig a ditch 3 ft. wide, 8 ft. deep and 500 ft. long, assuming the difficulty of working at night to be one-seventh greater than by day and the hardness of the ground in the smaller ditch to that in the larger ditch as 6 is to 5.

(3) The market quotation for Hemlock, Yellow Pine, White Pine, and Oak are $20, $30, $72, and $80 per M., respectively. The total cost of a certain job is $7,200, of which 60% is for lumber. Of the total cost of the lumber, 18% is oak, 12 × 14 ins.; 28% is white pine, 1 × 4 ins.; 34% is yellow pine, 6 × 10 ins., and the remainder hemlock, 2½ × 8 ins. Find the number of lineal feet of each.

(4) Find the sixth root of 2749.865307480007 to three decimal places.

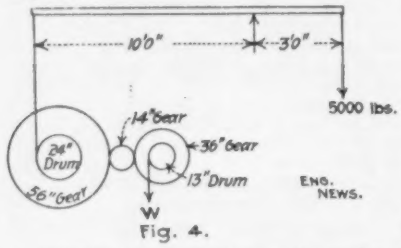


Fig. 4.

(5) A contractor buys cement at 43 cts. per bag, sand at 52 cts. per cu. yd., and broken stone at $1.10 per cu. yd. If the bulk of 7 bags of cement is 8 cu. ft. and the voids in the sand and stone are 35% and 42% of their respective bulks, find the value of the material used in making 67 cu. yds. of concrete of 1:2½:5 mixture, allowing 5% for waste.

GEOMETRY.

(1) What is the measure of the angles formed by two chords intersecting within the circumference of a circle? Prove the proposition.

(2) What is the area in square feet of a quadrilateral circumscribed about a circle whose radius is 48 ft., if the perimeter of the quadrilateral is 400 ft.?

(3) The volume of a certain cone of revolution is 1,200 cu. ins. and its altitude is 26⅔ ins. What is the volume of the rectangular prism whose base is circumscribed about the base of the cone and whose altitude is that of the cone.

(4) A regular hexagonal pyramid is circumscribed about a circular base, the perimeter of the circle being 117.8 ins. If the slant height of the pyramid is equal to the diameter of the circle, what is the lateral area of the pyramid?

(5) The apothem of a regular pentagon is 34.6 and a side is 50; find the perimeter and area of a regular pentagon, the apothem of which is 8.

ALGEBRA.

(1) Multiply $a^{\frac{1}{2}} - b^{-\frac{1}{2}} + 2a^{\frac{1}{4}} - 3b^{\frac{1}{4}}$ by $-2b^{-\frac{1}{2}} - 4a^{-\frac{1}{2}} - 6a^{-\frac{3}{4}} b^{\frac{1}{4}}$

(2) Solve, $\sqrt{3x+1} - \sqrt{9x+4} = \sqrt{2x-1}$.

(3) Expand $\sqrt[3]{1-2x-2x^2}$

(4) A and B run a mile race. In the first heat A gives B a start of 11 yards and beats him by 57 seconds; in the second heat A gives B a start of 81 seconds and is beaten by 88 yards. In what time can each run a mile?

(5) A gives to B and C as much as each of them has; B gives to A and C as much as each of them has; and C gives to A and B as much as each of them has; in the end each of them has $6. How much had each at first?

TRIGONOMETRY.

(1) Prove that sin 3x equals $3\sin x - 4\sin^3 x$.

(2) Derive the trigonometrical functions of 30°. Give the values of the functions of 0°, 90°, 180°, 270°.

(3) Prove that tan x plus cot x equals $\frac{2}{\sin 2x}$

(4) In any oblique triangle state and prove the relation of the sides and a function of the angles opposite and show how this is used to derive a formula for the solution of triangles in which a side and the adjacent angles are given.

(5) Given two sides and the included angle, derive a formula for use in obtaining the area of any oblique triangle. The angles being A, B, C, and the sides opposite a, b, c, find the area when b equals 20.25, c equals 30.27 and A equals 30°.

ANALYTICAL GEOMETRY.

(1) Given the general equation of the line

$$Ax + By + C = 0$$

what are the values of the following:

(a) The intercept on the axis of x.
(b) The intercept on the axis of y.
(c) The normal distance of the line from the origin.
(d) The tangent of the angle the line makes with the axis of x.
(e) If A, B, and C are all positive, in which quadrant does the normal lie?
(f) What relation must exist between the constants for the normal to lie in the first quadrant?
(g) If B and C are positive and A negative, in what quadrant does the normal lie?

(2) Find the equation of the circle whose center is at the origin of co-ordinates, and which is tangent to the line $3y - 9x = 11$.

(3) What is the equation of the chord of the circle $x^2 + y^2 = 136$ which passes through $-2, -7$; and is bisected at this point?

(4) For what point of the parabola $y^2 = 18x$ is the ordinate equal to three times the abscissa?

(5) Find the length of the line

$$\sqrt{3}\,y + x - 14\sqrt{3} = 0$$

intercepted by the co-ordinate axes. What angle does the line make with the axis of X?

CALCULUS.

(1) Find the first derivative of y with respect to x of

(a) $y = \log(3x^2 + x)$
(b) $y = x^n a^x$
(c) $y = \sin^2 x \cos x$
(d) $y = \dfrac{\tan x - \tan^2 x}{\sec^4 x}$
(e) $y = \tan \dfrac{x+a}{1-ax}$

(2) Find a quantity X, such that it shall exceed its cube by the greatest possible value.

(3) Integrate;

$$\int_0^a \int_x^{2x} \int_0^{xy} x^2\, yz\, dx\, dy\, z$$

(4) A rectangular box, open at the top, with a square base, is to be constructed to contain 300 cu. ins., what must be its dimensions to require the least material?

(5) Find the area included between the curve $a^2y = x^3 + ax^2$ and the axis of x, between the limits $x = -a$, and the origin.

SURVEYING AND INSTRUMENTS.

(1) Describe in detail the work of measuring an accurate base line for a topographical survey covering 500 square miles. What instruments are required?

(2) State how you would organize, and the instruments with which you would equip, a party for running a preliminary survey for the location of a railroad line. Describe in detail the process of making the survey, and the operations involved.

(3) Describe three methods of making a contour survey and explain when each would be used.

(4) Name in proper order the principal adjustments of the transit and describe how they are made.

(5) Sketch a longitudinal section through a wye level, showing the principal parts, including the position and shape of the lenses.

(6) Give field adjustments for wye level. How would you use a level which is out of adjustment to get accurate elevations?

(7) A tidal river, main channel 400 ft. wide, is to be dredged to a depth of 32 ft. at mean low water. It is proposed to pay for the work on the basis of place measurement. The exact location of the plane of mean low water is not yet known. A low sandy beach is parallel to channel. Describe how you would make all the necessary observations and how you would make hydrographic survey where soundings and estimates must be made quickly and often. State method of making soundings, equipment needed, precautions necessary to secure accurate work, and number and position of men required. State what method you would use to determine whether any small isolated rocks remain in channel on completion of work.

(8) On the sketch below (Fig. 1), the heavy line indicates the axial location of a ship canal which is to be 300 ft. wide on the bottom, side slopes 3 to 1, depth of water 30 ft., 20 ft. bermes on each side 6 ft. above the water. Plot on the sketch the plan of the completed cut, give a cross section at A, B and C and figure the volume of excavation between A and C.

(9) (a) It is decided to establish a naval station in Great Harbor, Culebra (see chart).

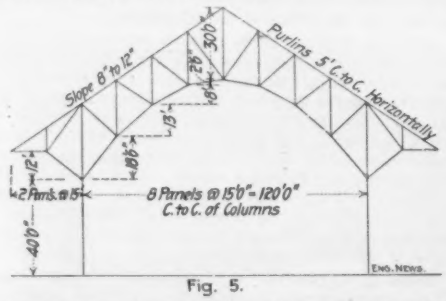


Fig. 5.

Indicate thus A on the chart, the location of primary triangulation stations for a survey of the harbor and adjacent region and connect them. Locate a suitable base and connect with the triangulation.

(b) State how you would obtain complete tidal data concerning the port.

(c) Make perspective sketch of harbor entrance and south shore of island from point marked A.

(d) Make a paper location of a railroad from San Ildefonso to Ensenada Fulladora.

(e) Plot the dangers to navigation given on the following sheet.

[(281) WEST INDIES-CULEBRA ISLAND-GREAT HARBOR-ROCK REPORTED.—Lieutenant C. M. Fahs, U. S. Navy, navigator of the U.S.S. "Olympia," reports the existence of a rock, with 18 ft. of water over it, outside of the Great Harbor, Culebra Island, which was discovered while surveying. The rock is located 1,270 yds. S. 12° 45′ W. true (S. by W. ¼ W. Mag.) from the house on the south beach of Punta Carenero, shown on U. S. Coast Survey chart No. 913.

(2025) PORTO RICO-CULEBRA ISLAND-GREAT HARBOR APPROACH—GROUPER SHOAL—ROCK TO WESTWARD.—Information has been received from Lieutenant C. M. Fahs, of the U.S.S. "Olympia," that while surveying he found a coral head or rock, some 6 ft. sq., with only 13 ft. of water over it. Its position as taken from the small house on the south beach of Punta Carenero, is S. 3° W. true (S. ¾ W. Mag.), distance 1,060 meters (1,159 yds.).

The rock lies right in the western channel leading along the reef toward Great Harbor. A buoy, No. 2½, has been placed about 10 ft. to the westward of the rock in 7½ fathoms of water to mark its position.]

PHYSICS.

(1) Show by diagram the principle of the ordinary sextant.

(2) Show how the position of metacenter affects the stability of a floating body.

(3) What weight placed 2 ft. from the axis of a wheel will balance a weight of 18 lbs. placed 4 ins. from the axis, while the wheel is revolving?

(4) Give three methods for the transmission of heat and illustrate by examples.

(5) Define specific gravity. Describe method of obtaining the specific gravity of Portland cement, and state what specific gravity you would expect to obtain.

(6) Explain the principle of the screw jack and illustrate by diagram the actual power required at the end of a 30-in. lever, to lift a weight of 10 tons, the pitch of the screw being five turns per inch. The diameter of the screw is 3½ ins.

(7) In what proportion must water at a temperature of 30° and linseed oil (specific heat 0.5) at a temperature of 50° be mixed so that there are 20 kilograms of the mixture at 40°?

(8) What is the relation between the graduations on the three standard thermometers?

(9) The diameter of a steam engine cylinder is 9 ins.; the length of crank, 9 ins.; the number of revolutions per minute, 110; the mean effective pressure of the steam, 35 lbs. per sq. in. Find the indicated horse power.

(10) Two bodies are let fall from the same point at an interval of two seconds. Find the distance between them after the first has fallen for six seconds.

GEOLOGY.

(1) Name the principal rocks, describe their formation and composition. What is the primary division of rocks?

(2) What are anticlines; cynclines; faults? What are the dip and strike of strata? What are unconformable strata? What is meant by metamorphic rocks and what are the principal ones? What their composition? What is the most common sedimentary rock and what is its composition?

(3) What is a glacier, describe general characteristics and name three well known ones.

(4) What is an iceberg and how formed? Upon what does the erosive power of a stream depend? Explain what ratio governs its transporting power.

(5) Outline in briefest form present theories as to seismic and volcanic action.

ENGINEERING CONSTRUCTION.

(1) Make a detail drawing of the roof truss and columns shown in Fig. 2.

Allow 10,000 lbs. per sq. in. shearing value on rivets.
" 20,000 " " " " " bearing value on rivets.
" 250 " " " " " pressure on bed plates.

The maximum size of members which can be shipped is 11 ft. wide by 35 ft. long. Purlins to be 10 ins., 15 lbs. channels at each panel point.

(2) Make sketches showing construction of a concrete-steel floor and describe briefly the materials and construction.

(1) For a warehouse, floor beams to be 6 ft. on centers, load 500 lbs. per sq. ft.
(2) For an office floor beams as in "I," load 100 lbs. per sq. ft., to have a wooden wearing surface and suspended ceiling beneath.
(3) For a toilet room, floor resting directly on the ground.

Make sketches of a terra cotta floor end construction.

(3) Make sections showing the construction of a double-hung window in an office building with brick walls. Name all parts. Show construction of a 4-in. terra cotta partition plastered both sides. Of a 2-in. solid plaster partition and door frame. What is the maximum height for which the above partitions should be used?

MASONRY AND FOUNDATIONS.

(1) Give the different kinds and qualities of brick used for ordinary building construction. State for what class of structures each is sued and the method of laying each to secure the best results. What precautions should be observed in laying brickwork in this vicinity as regards conditions of weather? When may lime mortar be used and when, never used?

(2) Give the usual methods employed to determine the bearing power of soils, making detailed sketches where necessary.

(3) Using an ordinary drop hammar weighing 3,000 lbs., the loaders being 60 ft. in length, state what formula you would use to determine the bearing power of piles, discuss the formula, and discuss also the process of driving piles, stating which methods to employ and which to avoid in order to secure the best results, paying special attention to height of fall.

(4) A column of a certain tall building supports 360 tons total load. The material of the building site will support 1½ tons per sq. ft. safely, and piles cannot be used. Design a foundation in steel and concrete with pedestal for Z-bar column of 4 Zs 6×¾, 1 pl. 8×¾, and 2 pls. 14×¾. The foundation is limited in length to 20 ft.

1 = 795 for 18-in. I-beam.
1 = 609 " 15 " "
1 = 268 " 12 " "
1 = 122 " 10 " "
1 = 57 " 8 " "

(5) A masonry pier supporting a highway bridge is to be located in a stream at a point where the depth of water is 11 ft. at normal stage. The bottom is mud with hard clay at a depth of 40 ft. The roadway is 35 ft. above normal stage of water and the greatest recorded flood stage is 15 ft. Make sketch showing pier and foundation, also sketches of such auxiliary construction as may be employed. Dimensions required.

MECHANICS.

(1) A column supports two crane girders 20 ft. and 24 ft. long respectively (Fig. 3). The rolling loads on these girders are as follows and always have the same relative order with respect to the spans. Find the maximum loan

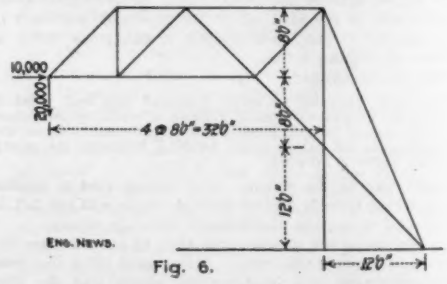


Fig. 6.

on the column and the maximum shear at the end and center of the 24-ft. span.

(2) A beam inclined to the horizontal at an angle of 30° and carrying a uniform load of two tons per horizontal foot, rests against a vertical wall at its upper end and is anchored to a pier at its lower end; the distance from face of wall to center of pier is 25 ft. If the pier is 10 ft. high and of square section, what must be its size to insure stability, the weight of masonry being 150 lbs. per cu. ft.?

(3) A certain arch is 2 ft. 6 ins. deep at the keystone and has a rise of 5 ft. and a clear span of 60 ft. If the total uniform load, including the dead weight, is 2,000 lbs. per sq. ft., find the pressure per square inch at the

center, the reactions at the abutments and show the method of obtaining the line of pressures.

(4) A column 32 ft. high is securely anchored at the base and loaded with 150,000 lbs. on top and 60,000 lbs. 24 ft. above the base and 18 ins. from the center line of the column in the plane of the web. If the column is an I-section, composed of a web plate 16 × ½ ins., and four angles 6 × 3½ × ½ ins., with the 6-in. leg at right angles to the web, what is the maximum fiber stress in the column?

(5) The top chord panel of a roof truss, composed of two 6 × 3½ × ½-in. angles of 5-ft. clear span, has a direct compressive stress of 98,000 lbs. and supports a uniform beam load of 600 lbs. per ft. of span. What is the combined stress per square inch? The I of the section is 33.2.

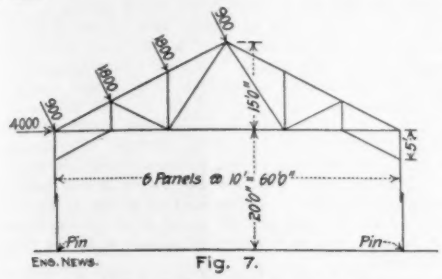


Fig. 7.

(6) A cone of revolutions whose base is 10 ins. diameter and altitude 15 ins. is immersed, vertex down and base parallel to the surface of water. The base is 10 ft. below the surface. Find the pressure on the conical surface and the tendency of the body to rise to the surface.

(7) A concrete well is built in a reservoir. The height of the wall is 35 ft., the elevation of the outside water 30 ft. and the interior is pumped out to a depth of 8 ft. from the bottom. If the wall is 18 ins. thick, what is the pressure per square inch in the body of the wall at a depth of 30 ft. from its top? Diameter of well = 40 ft.

(8) The weight of bituminous coal being 50 lbs. per cu. ft. and its angle of repose 45°, design a wall to retain coal 18 ft. high, flush with its top. What modification must be made if the coal is piled at its natural slope, its toe being at the top of the wall?

(9) Define the following:

Moment of inertia,	Modulus of elasticity.
Center of percussion,	Resilience,
Radius of gyration,	Factor of safety.
Elastic limit.	

(10) What weight "W" is necessary to balance the load of 5,000 lbs. (Fig. 4.)

STRESSES IN STRUCTURES.

(1) A train-shed roof is supported by trusses spaced 20 ft. on centers on an outline shown on accompanying sheet. The total load on the roof is 60 lbs. per sq. ft. Find the stresses in the truss graphically and proportion the members. What unit stresses would you allow? Make a sketch showing arrangement and size of lateral bracing you would use for first four panels from outer end of shed. Show stresses on left half and sizes on right half of diagram (Fig. 5).

(2) Find stresses in frame (Fig. 6) analytically.

(3) Determine stresses in frame shown above (Fig. 7) for loading given. The column is a stiff member from the pin at the ground level to the bottom chord of the roof truss.

PAVEMENTS.

(1) Specify all the materials and the finish of a granolithic sidewalk.

(2) Sketch cross-section and describe materials and construction of a street 91 ft. between lines, laid out as follows: Double track street railway in center, 4 ft. 8 ins. gage, 10 ft. 4 ins. centers, paved with granite blocks; on each side of a track a roadway 18 ft. wide, paved with asphalt; gutters, 2 ft. wide each, of vitrified brick; granite curbs; cement sidewalks, 8 ft. wide; parking, 10 ft. wide. Indicate on the sketch the various sub-constructions in the street and their connections.

(3) What crown would you give to street paving? What minimum grade of gutters? What do you consider to be the limiting grades for asphalt paving, vitrified brick, granite block, macadam? Why?

MATERIALS OF CONSTRUCTION.

(1) Write a specification for good building sand and for gravel for foundation concrete. What should be the size of sand particles to make the strongest mortar?

(2) Write a specification for paving brick; describe tests that should be made on same.

(3) Why is open-hearth steel preferred to Bessemer for structural material? With open-hearth steel, would you prefer basic or acid for structural material? Why?

(4) What is Rosendale cement? Describe its manufacture. What do you understand by Portland cement? Describe its manufacture.

(5) Write a specification for lime to be used in the construction of a brick building. Specify the mixing of mortar for the above.

(6) What is the composition of commercial roofing plates of so-called tin? How are they made? How is the thickness of copper for roofing purposes specified? What are its advantages over tin or galvanized iron?

(7) Discuss rusting of steel and methods of preventing by painting. What paint would you use on sheet steel roofs? On corrugated steel sides? On steel framework of buildings? Why?

(8) What kind, grade, and quality of wood would you specify for a timber wharf, above the tops of the piles? For a railroad trestle? For railroad ties? For the floor of a shop? For the floor of an office? For a shingle roof? For the frames and siding of a wooden building? For the doors and windows of a dwelling?

(9) A circular pump well 30 ft. in diameter, with concrete bottom and sidewalls about 4 ft. thick, is to be made waterproof against a maximum head of water of 30 ft. Design and specify material and workmanship for waterproofing.

(10) Name the various kinds of glass manufactured and state the purposes for which generally used.

WATER-WORKS.

(1) A 12-in. pipe on a grade of 3 ft. per thousand is flowing half full. Assume a coefficient of friction, and find the discharge of the pipe per second.

(2) Write an outline specification for the laying of 16-in. cast-iron water main in this vicinity to carry a working pressure of 125 lbs. Describe briefly the most important features to be looked after to secure the best results. Part of the main is laid in rock and part in very soft wet ground. The thickness of the pipe above is ⅜-in. What is the stress per square inch in the metal?

(3) A town of 40,000 inhabitants is to be supplied with water for domestic consumption at an average rate of 60 gallons per capita per diem. The water is furnished from a reservoir through a cast-iron pipe line two miles long, to a center of distribution in the town. Give the size of pipe necessary. The water level in reservoir is 200 ft. above center of distribution and located on comparatively level ground. Sketch a section and give area of a square reservoir with concrete core wall and earth embankments to contain a 30 days' supply. Location of reservoir is in good sand and clay mixed.

RAILWAYS.

(1) What are the relations between frog number, throw, lead, gage, radius of curvature, etc., of a turn out? Describe each, and give formula. What is the minimum radius of curvature you would use for Navy Yard work where standard gage cars are to be shifted?

(2) Sketch a section through a steam railroad track suitable for permanent construction in a street paved with vitrified brick or granite blocks.

(3) Make a sketch plan of a set of crossing frogs for standard gage steam railroad tracks, the angle of the crossing being 60°, and the traffic over the crossing being heavy and at considerable speed.

(4) Make a sketch of a spring rail frog, and of a solid filled bolted frog.

SEWERS.

(1) Design the sewers as shown on the accompanying sketch (Fig. 8), figuring the sizes, locating manholes, catchbasins, etc. The river bank is at M. H. W. and the point A at 15 ft. above M. H. W. with uniform grade toward river. The sewer is of the separate type and the water consumption is to be figured at 100 gallons per capita, with 300 residents on each block. No provision for growth of city.

(2) What data are required for the design of a combined system of sewers and how would you proceed to calculate the conduits?

WHARF.

(1) A timber pier 300 ft. long and 60 ft. wide is to be built projecting into a tidal river with mud bottom, varying from mean low water at the shore to a depth of 18 ft. at M. L. W. at the outer end. After the construction is completed berths are to be dredged on both sides to a depth of 25 ft. at M. L. W. The height of the deck above M. L. W. is 14 ft. The test piles driven to determine the bearing power of the bottom showed a total penetration below M. L. W. of about 36 ft., bringing up with a penetration of 1-in. per blow of a 2,800-lb. ram falling 20 ft. Design the wharf, showing neat free-hand sketches of the principal details. Make a complete bill of material and estimate the cost of all items to be purchased.

BOILERS.

(1) Design a battery of boilers of the return fire tubular type, to supply 500 HP. at a steam pressure of 100 lbs. per sq. in. The grate surface, area over the bridge wall, flue area, and general dimensions of chimney, all to be fully shown.

(2) What is the rate of coal consumption per horse-power for the boilers of problem 1? How much water is evaporated per pound of coal? What is the ratio of heating surface of grate surface? How much heating surface is required per horse power?

(3) Give full details of a complete boiler test to determine efficiency.

(4) Describe briefly the several types of condensers in use.

EXPERIENCE WITH ANCHOR ICE AT THE DETROIT WATER-WORKS AND ELSEWHERE.*

By C. W. Hubbell,† Assoc. M. Am. Soc. C. E.

It is the purpose of this paper to describe in detail anchor ice difficulties and attempted remedies at the Detroit Water-Works. Trouble began when the first intake pipe was laid in 1840. At that time, however, the strainer was near the end of the pier and ice was removed from it with long poles.

In 1858, a 30-in. boiler-iron intake was extended into the river about 150 ft. beyond the end of the pier. The strainer was a boiler-plate cylinder 9 ft. in diameter and 10 ft. high, with a dome top, perforated with ½-in. holes, 144 to the square foot. This strainer was set on the bottom of the river in a current running three miles per hour, in water 34 ft. deep, the depth of water over the top of the strainer being 25 ft. The flow through the strainer, at normal capacity, was 3,780 gallons per minute.

In the early years, Detroit had a reservoir of sufficient capacity to supply the city during any short period of stoppage. In 1865, it is stated that for one entire week the engines were able to obtain a supply through the strainer only during the middle of the day; the reservoir was sufficient to carry the excess of consumption. A strainer constructed of wood was recommended at this time; it was believed that ice would not adhere to wood as it did to iron.

In 1866, a self-acting swing door, 19 × 16 ins., was put on the down-stream side of the strainer. This, however, did not afford material relief; and it was recommended that a larger door be added. The wooden strainer and larger door were not immediately built.

The water board appointed a special committee to investigate the entire subject. The door set in 1866 gave but little relief, and was permanently closed. The following fall, a line of booms inclosing a considerable area over the strainer was kept in position until the ice formed inside it, but failed to give relief unless the entire river was covered with ice.

The committee continued its investigations; and, in the summer of '68, divers were employed to build a submerged platform of planks immediately over the strainer, resting on some thirty piles. It was hoped that such a platform would prevent the radiation of heat from the strainer, which would remain at a temperature sufficiently high to prevent ice from adhering to its surface. The platform, however, proved worse than nothing, as stoppages occurred at a higher temperature than before. On Dec. 9, the strainer was completely plugged up, with a temperature of only 26°. A diver was sent down and found the strainer and surrounding piles covered with a mass of ice crystals 10 ft. high and 15 ft in diameter. The entire body of water was filled with crystals of ice, from the surface to the bottom of the river; these were rapidly adding to the volume of the mass already collected, as the current brought them swiftly down. Samples of the crystals were brought to the surface, and for the most part consisted of sheets and particles thin as paper, with sharp jagged edges. The mass of ice was thickest on the up-stream side of the strainer, a small portion of the down-stream side being nearly free from ice. It was thought that if the strainer could be inclosed on the up-stream side, leaving the down-stream side only exposed, the difficulty would be done away with. A large piece of canvas was fastened around the piles and to the covering platform, completely inclosing the strainer except on the down-stream side. This was but just completed when the weather again turned cold, the temperature dropping slightly below the freezing point. Before daylight, the engine was compelled to stop, there being absolutely no water coming through the strainer. The wooden platform and canvas were then entirely removed; and no further difficulty was experienced until Dec. 24, when the surface ice in the river was in motion, the thermometer standing at 16°. No water could be obtained from 1 o'clock until daylight. Trouble usually occurred when the river was free from surface ice and the temperature from 8° to 20°. No trouble occurred when the river was covered with ice, no matter how severe the cold. The greatest number of detentions were at night or when the sun was obscured by clouds. With an unclouded sun, no difficulty was ever experienced; and difficulty soon ceased when the temperature exceeded 20° above zero.

The final recommendation of the committee was the entire removal of all piles and other obstructions adjacent to the strainer. It was believed that "with nothing but the smooth dome of the strainer for ice particles to lodge upon, the quantity which would accumulate could not very seriously prevent the flow of water to the inlet pipe." One year after the recommendations of this committee were presumably carried out, the following entry was made: "The engine was stopped by ice 16 times during December, and frequently had to run at slow speed for want of supply."

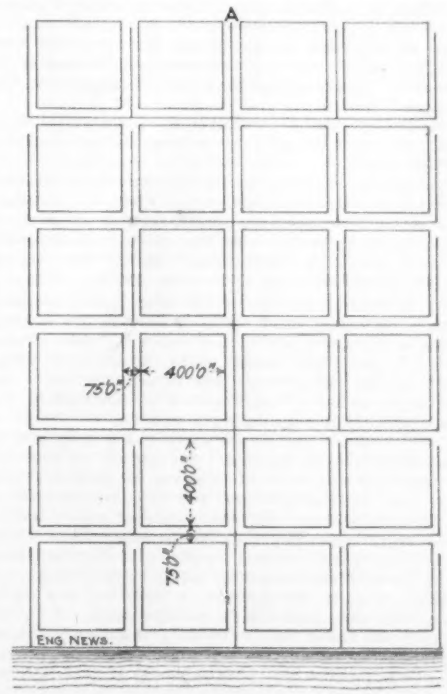


Fig. 8.

The increasing demand for water and the inadequacy of the reservoir to carry the city over periods of ice trouble caused the board much anxiety. In 1869 it was decided to make a second trial of a self-acting door. In design it was similar to the one tried in 1866, except that it was of larger size, being 36 × 48 ins. This door was placed on the top of the strainer box and afforded limited relief. On Dec., 21 of that year trouble occurred; however, it was not necessary to completely stop the pump

*From "The Michigan Technic" for 1903, University of Michigan.

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and the door furnished a supply equivalent to 2,850 gallons per minute.

In 1871, the intake pipe was extended 100 ft. farther into the river. The holes in the old strainer were increased from ½-in. to ¾-in. in diameter, and two additional strainers were put on the outer end of the pipe. The two new strainers were about 9 ft. in diameter, 20 ft. long, and were laid horizontally upon the bottom of the river, extending up and down stream. The top half only was perforated with holes ¾-in. in diameter. The object of supplementing the old strainers with two new ones was "to remedy the accumulation of ice on the strainer in winter;" followed by the rather pathetic statement, "I am sorry to say that this has not been wholly accomplished."

During the summer of 1873, a second intake pipe was laid at the old works at the foot of Orleans St. This pipe was 3 ft. in diameter and was provided with four strainers. The water was taken in through wooden gratings made of slats, ½-in. opening, all on the down-stream side so that the direction of the flow of water must be reversed in order to enter the strainer. It was hoped that this arrangement would allow much of the sediment and ice held in suspension to pass by. The outer strainer was provided with a door on the top which could be opened from the shore by a rod passing inside the pipe, thus permitting the free entrance of water in case the grating became blocked by ice. At the time the annual report was made, the weather was favorable for anchor ice upon one occasion only; no trouble, however, occurred. From this time until these pipes were abandoned in 1877, the official reports of the board make no further mention of anchor ice difficulties. It is therefore fair to presume that the increased capacity furnished some measure of relief, although probably not entire immunity.

The new works were located at the present site four miles above the center of the city. The first intake laid was of boiler-plate, 60 ins. in diameter, 1,000 ft. long. The strainer was built of timber, 57 ft. long, 7 ft 8 ins. wide, and 6 ft. high. This box was placed at right angles with the current in water about 27 ft. The strainer bars were set on the down-stream side and were of white oak, 3 ins. wide, ⅜-in. thick on the front edge, tapering to ½-in. on the back edge. The bars were placed to give a clear opening of ½-in. on the front edge. This intake delivered water into the present settling basin, which is 365 ft. wide by 775 ft. long, with a depth of 13 to 17 ft.

The new works were put in service Dec. 15, 1877. In the afternoon of Dec. 7, 1882, the wind changed to northwest and blew a gale. At 6 p. m. the thermometer stood at 9° above zero. At 10.30 p. m. the water in the settling basin was lowered 7 ft. on account of the accumulation of anchor ice around the strainer in the river. The following morning at 1 o'clock the thermometer stood 5° above zero. At 8 a. m. the water began to rise, and at noon was at the usual height. In the meantime, the wind had gone down and ice had formed over the strainer in the river. A second inlet pipe was recommended at this time.

On Dec. 17 and 19, 1883, the same trouble recurred, the water in the settling basin being lowered about 4,000,000 gallons.

During the following season, the second intake pipe was completed, 72 ins. in diameter, similar in construction to the first; and when trouble from ice occurred on Dec. 18, 1884, the new pipe was so far completed that it could be opened. This relieved the difficulty, and no further trouble occurred during that season.

The strainer at the end of the 72-in. pipe is provided with a self-acting relief valve. There are two strainer boxes, each 5 × 6 ft., 30 ft. long, set 65 ft. apart. These boxes are set at right angles to the current, water being taken on the down-stream side through vertical white oak slats, as above. Each section is connected to the valve chamber by pipes 4½ ft. in diameter.

Nov. 7, 1886, the reservoir, which had been in service since 1857, was discontinued. The surface of water in the reservoir was about 77 ft. above the surface of the river, and the discontinuance was necessary on account of the growth of the city, which extended rapidly northward to ground higher than the reservoir itself. The cutting out of this reservoir, which held 10,000,000 gallons, removed one safeguard against water famine by anchor ice, as it was sufficient to carry the city for a short time, even with the pumps shut down.

Late in the fall of 1886, a new set of plate-iron strainers with cast-iron relief valve box was made to replace the old wooden strainer box at the outer end of the 5-ft. inlet pipe.

In 1888, Belle Isle bridge was constructed; and the engineer reports that the bridge abutments stopped the surface ice and caused a cover of ice to form over the strainer much sooner than before, which lessened the danger of anchor ice.

During the season of 1888, a short brick conduit was laid from the settling basin to the bank of the river. This was not provided with a strainer, and remained closed except in case of complete stoppage of the outer end of the two regular intake pipes. The emergency conduit was used only once the first winter after it was built; then several years followed during which it was not used at all, there being no trouble from ice.

In 1889 every other slat was removed from one of the strainers, which increased the size of opening between the slats from ½ to 1¾ ins. In 1890 a third inlet pipe, 6 ft. in diameter and 1,500 ft. long, was laid. The strainer was similar to the others in construction, but the strainer box was laid horizontally with the current instead of across it, and the opening between slats was made 1¾ ins. About this time, the strainer box on the 5-ft. intake first laid was rebuilt, and also placed up and down stream instead of across the current.

For a period of ten years there was entire freedom from ice trouble, and those in charge believed that the increased area of the strainers, together with the new position in which they were placed and the effect of the bridge abutments in causing surface ice to form earlier in the season, had effected a permanent cure. As a matter of fact, however, these things had little to do with the cessation of trouble, the true cause of which appeared later in the following manner:

In 1897 and 1898 a sanitary survey was conducted by the engineering department to ascertain the point at which the purest water available could be obtained. In this survey an electric thermophone was used to determine temperatures. It was found that the temperature of the water in the river at a point opposite the water-works, two miles below Lake St. Clair, was practically uniform from top to bottom. The current is about 2½ miles per hour, and the depth of water 30 ft. The variation between top and bottom was seldom as great as 0.5° F., and was usually not more than 0.1° or 0.2° F. At certain times, however, a marked difference was noticeable in the temperature of water near shore and at mid-channel, probably due to the effect of sun in the shallow water and to the entrance of shore water. On three different days, when the temperature of the shore water was colder than at mid-channel, the following results were obtained:

Temperature of water at intake crib.....	38.8° F.
Temperature of water near shore.....	36.8° F.
Temperature of water entering settling basin....	36.9° F.

On three other days, when the shore water was warmer than that in the channel, the following results were obtained:

Temperature of water at the intake crib.....	41.4° F.
Temperature of water near shore.....	43.3° F.
Temperature of water entering settling basin....	43° F.

It will be noted that the temperature entering the settling basin corresponded very closely to the temperature of shore water. It was at first assumed that water entering at the outer end was changed in temperature to correspond to the shore water through which the intake pipe passed. The possibility of breaks near shore was considered unlikely, and no examination of the pipes was made until the fall of 1899 and spring of 1900. Divers then found that the joints in the 5-ft. pipe were leaking badly, and the two 6-ft. pipes were broken off entirely at a point near shore. In one case there was a space of 4½ ft. between two consecutive lengths of pipe; and in the other, two sections, each 25 ft. long, had been carried away entirely and were found some 20 or 30 ft. down stream from the line of pipe. The indications were that at least one of the pipes had been broken by dredges which were known to have anchored in that vicinity shortly after the pipe was laid in 1890; marks of the dredge dipper were quite distinct. The protection afforded by a breakwater a short distance above and booms inclosing ice areas, caused surface ice to form early in the season over the open ends of the broken intakes and for a considerable distance above them. The freedom from anchor ice which had been experienced for some years past was fully explained; but as the supply at this point was known to be more or less dangerous on account of pollution, repairs were made at once. At the point at which the break occurred, the water was comparatively shallow with little current.

In the meantime the emergency conduit, laid in 1888, had been discontinued because it seemed unnecessary. Repairs to the intake pipes were completed in the summer of 1900; and during the following winter the cribs were stopped with ice several times, but thanks to the settling basin which held a reserve of nearly 17,000,000 gallons, it was not necessary to stop the pumps.

The following summer an emergency valve was placed on one of the 6-ft. pipes near shore, and a platform extended to it in such a way that it could be operated in case of difficulty at the cribs. It was thought that this would prove effective, from the fact that the open end of pipe had so long been so. Unfortunately, however, the location selected for the emergency valve was immediately above the water-works dock and ice crystals coming down the river accumulated on the up-stream side of the dock and around the valve, making it necessary to operate the valve on an average every 20 minutes in order to keep it free.

In the winter of 1901-1902, the trouble from anchor ice at the cribs was more severe than in the preceding season, although by constant effort a considerable supply was obtained through the emergency valve. Twice it was necessary to put the city on short supply, and we were saved frequently only by the reserve supply in the settling basin. The old emergency conduit was reopened, and since that time has been used on several occasions.

Again, on Dec. 12, 1902, the supply was cut off for a few hours. The trouble at this time, however, was not at the river but in the strainer wells which connect the settling basin to the pumps. These wells are fitted with boiler-plate strainers ⅝-in. thick, with 7-16-in. holes, ¾-in. c to c. The strainers are built into the solid masonry to prevent fish, lizards and other foreign substances from damaging the pumps and entering the city mains. The trouble was first noticed about 4.30 a. m. The temperature was about 17° above zero. No surface ice had yet been formed on the river or settling basin. A slight breeze was blowing which ruffled the surface of the settling basin, and the crystals of ice which seemed to permeate the entire mass of water were drawn into the basin outlets and lodged against the screens, completely plugging them. No trouble had ever before occurred at this point, and was not anticipated. The screens were cut with chisels, and water, ice and all, let onto the pumps about 9 a. m. This procedure, although involving some risk to the pumps, resulted in no damage. The screens are now provided with sliding sections which can be removed, leaving only a coarse bar screen which can be readily raked by hand. Before another winter approaches platforms will be built in front of the basin outlets, which it is believed will be sufficient protection until the basin freezes over.

On account of the expensive repairs and the general unsatisfactory condition of the boiler-plate intake pipes, the water commissioners are now constructing a tunnel 10 ft. in diameter which will extend under the river at a depth of about 70 ft. to a point near the head of Belle Isle where the water is 30 ft. deep. The intake crib will be of concrete construction, coming to the surface. It will have a cut-stone superstructure. The water will enter the intake through 24 cast-iron ports 48 ins. in diameter. The ultimate maximum capacity of the tunnel will be at the rate of 150,000,000 gallons per 24 hours; and the maximum demand at the season during which anchor ice is likely to form, will be about 100,000,000 gallons per 24 hours. This will give a velocity of a trifle less than 9 ins. through the ports. With the consumption as at present, the velocity through the ports during periods of anchor ice would not exceed 5 ins. per sec. Each port will be provided with a screen of slats leaving space about 4 ins. wide. These screens can be removed by employing a diver. To provide further protection, a 125-HP. steam boiler will be set up on the crib, and two of the ports on the down-stream side will be surrounded by steam pipes, and a circular steam-pipe at the entrance to the port will be perforated in such a way that a steam jet will loosen any ice which may adhere. These two ports will have no screens and will remain closed except in case of trouble. An open trench will also be provided on the down-stream end of the crib; if necessary, this trench can be kept open by means of men with rakes. The trench will ordinarily be closed off by a bulkhead, and will be provided with bar screens to prevent cakes of surface ice from entering. The trench and down-stream ports, including the two fitted with steam-pipes, will be partially protected in winter by a boom which will inclose several hundred square feet and will tend to cause the early formation of an ice covering. A water jet from a fire pump will also be available if required.

GENERAL CONCLUSIONS BASED ON EXPERIENCE AT DETROIT AND ELSEWHERE.

The following general conclusions are based in part upon available published data, and in part upon personal experience and inquiry.

Danger from ice is ever present throughout northern cities. The trouble is of three kinds—first, surface ice; second, frazil or needle ice; third, anchor ice.

Trouble from surface ice is principally confined to large lakes. When driven by a gale, it piles up on shore to a considerable depth, sometimes completely surrounding an intake, and shutting off the supply. This has occurred at the old Cleveland crib, and is quite common at the Buffalo intake. In such cases, dynamite is sometimes used to clear away the ice. There is danger also to intake pipes which are laid in shallow water, as they are frequently displaced or broken from this cause. A large field of shore ice inclosing a surface crib may do considerable damage when it moves out, as was the case at the new Cleveland crib. Ice fields coming from the open lake are broken up and have not the force that a field of shore ice has when it first starts to move. Submerged intakes along the west shore of Lake Michigan have frequently been disturbed. In water less than 30 ft. in a large lake there is very little choice between surface and submerged intakes, so far as surface ice is concerned. Snow and needle ice, when driven by wind, have the same effect as surface ice on the shore against which they pile up. Ice of this kind seldom reaches a depth exceeding 30 to 35 ft.

Frazil or needle ice causes sorrow in large lakes, small lakes, rivers and reservoirs. It is composed of crystals of ice formed in open water. These crystals have a specific gravity of about 0.91 and are little, if any, heavier than ordinary ice. If they are formed in quiet water, they immediately unite to form surface ice; but if formed in a flowing river or any agitated water they are prevented from immediately uniting and are carried below the sur-

face ice by eddies and currents. In a river the crystals so formed consist of spicules of ice about the size and shape of a 6-in. lead pencil and thin sheets no thicker than paper, which soon permeate the entire body of water. Experiments on the St. Lawrence River with very delicate instruments have demonstrated that the temperature of water at such times is never more than 0.01° F. below the freezing point, and is the same at all depths. When the water rises in temperature 0.01° above the freezing point, the crystals of ice begin to disappear. In bodies of quiet water, such as lakes and reservoirs, the depth to which crystals will descend appears to depend solely upon the depth to which surface agitation by the wind is felt. Frazil or needle ice is never formed where there is surface ice, although it is often carried under surface ice for a considerable distance in the case of rivers. In the St. Lawrence it has been carried, in some instances, ten or twelve miles, and when reaching quiet water has floated to the surface, attaching itself to the under side of surface ice, and formed in great hanging masses sometimes 80 or 90 ft. deep. The winter floods at Montreal are due to the contracted waterway caused by such masses of needle ice. In the case of water-works intakes, it requires only a very slight current to draw particles of ice down from the surface. A velocity of only 0.2 ft. gives a velocity-head sufficient to overcome the buoyancy of a particle of ice 0.016 in. thick; and as the particles of ice are frequently in the form of very thin flakes, they will be drawn against screens even at this low velocity. A velocity of 1 ft. per sec. is sufficient to overcome the buoyancy of a particle of ice 0.42 in. thick. It is usually recommended that the mean velocity through intake ports be not greater than about 0.5 ft. per sec. Particles of ice, when drawn against a screen, are difficult to dislodge; rakes, mechanical scrapers, moving bars, chains, ice elevators, compressed air, and steam, have all been used to accomplish this purpose. The most effective way to overcome difficulty from needle ice in the case of deep lakes, is to build submerged intakes at a depth of 40 ft. or more; it appears that needle ice never reaches that depth except in the case of rivers. The new submerged intake at Milwaukee has 46 ft. of water over the top of the strainer bars; the crib at Duluth has 56 ft. of water over the top of the strainer bars; and the crib at Toronto is in 80 ft. of water. These have never been troubled with either surface ice, needle ice or anchor ice. In smaller bodies of water a less depth would be effective; and in reservoirs a platform of sufficient area placed above the intake will often distribute the velocity and prevent needles of ice from descending. Where feasible, submerged intakes are greatly to be preferred as compared with surface cribs, on account of their smaller first cost and low maintenance charges; they are not suitable, however, for rivers where needle ice reaches to the bottom, no matter how great the depth may be. This is especially true for large cities. In the case of small towns, air or steam may sometimes be successfully employed to free a submerged strainer, even in a river where the needles of ice are floating like so much waterlogged sawdust. Air pipes are apt to freeze up on the inside and steam cannot be carried very far on account of condensation. A reversed current of water from the pumps is sometimes effective.

Anchor ice is ice which forms upon submerged bodies, due to the radiation of heat which takes place through water and air into space. This form of ice does not occur at depths exceeding about 40 ft. Unlike needle ice, it sometimes occurs underneath surface ice, but only when the surface ice is thin and clear. Anchor ice forms more readily upon dark substances than upon those of lighter color; iron especially is subject to heat radiation, and for that reason wooden strainers are preferable. True anchor ice is largely supplemented by needle ice, which is readily attached thereto. Anchor ice sometimes forms on the bottom of a river to a depth of 2 to 3 ft.; in such cases it is made up to a considerable extent of crystals and is spongy in its nature. Anchor ice has the same specific gravity as other ice, and rises to the surface as soon as it has attained sufficient thickness to lift the object to which it is attached. Anchor ice does not form when the sun is shining, and a few hours of sun are sufficient to detach it from stones at the bottom of a river or from intake cribs; in fact, there is usually no trouble at all with water-works intakes when the sun is shining, as at such times needle ice readily passes through the strainer bars and enters the intake pipe or conduit. Stoppage never occurs in brick conduits, although needle ice in large quantities may pass through; stoppage sometimes occurs, however, on the inside of wrought or cast-iron intake pipes, where they are exposed to radiation. In the case of the Detroit tunnel, it is estimated that the heat which will be absorbed from the surrounding soil will be sufficient in one hour to melt a coating of ice about 0.05 mm. thick.

A reservoir is one of the best safeguards against water famine from ice in the strainers.

Following this article will be found an index of literature upon the general subject of ice formation and trouble, so far as the writer has been able to compile it.

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NOTES ON A SUBAQUEOUS ELECTRIC POWER CABLE.

In an article on the water-power plant at Chaudière Falls, P. Q., in Engineering News of May 7, 1903, we described also a subaqueous cable by which electric power from this plant is transmitted across the St. Lawrence River from the city of Levis to Quebec. The conditions under which a subaqueous power cable has to work are rather more severe at this location than elsewhere, which fact, together with the successful laying of the cable in winter, when the river was covered with ice, lends special interest to this transmission. We stated in that article that "the cable has been in continuous use . . . and the transmission is giving complete satisfaction." This seems to be not strictly true, as appears from a paper by Mr. G. U. G. Holman, of the Canadian Electric Light Co. (the company operating the cable), read before the Canadian Electrical Association at its recent convention in Toronto. We reprint this paper in the following, slightly condensed.

It must be remembered that subaqueous cables carrying large amounts of electric power, especially in alternating current and at moderately high voltage, are not very plentiful as yet and not much experience with them is available. But it is likely that in the future many cases will arise where electric power in considerable amounts is to be transmitted across water courses, rivers, or larger bodies of water; the solution adopted at Carquinez Straits, in California, of an aerial crossing by steel cables suspended from towers, will prove feasible or economical only in exceptional cases, while in all other cases subaqueous cables must be adopted. These cables will have to carry alternating current, at a tension probably much lower than what we now consider proper for long-distance transmission, but yet at moderately high voltgage, from 2,000 up to 5,000 or even 10,000 volts. The Levis-Quebec power cable, operating under 2,200 volts and carrying about 1,000 HP., is of this class.

The submarine power cable belonging to the Canadian Electric Light Co., which supplies 1,000 HP. to the Quebec Railway, Light & Power Co. in the city of Quebec, is laid on the bed of the St. Lawrence River, the terminal cable bells being approximately 3,400 ft. apart. The cable was laid amid floating ice on Dec. 18, 1901; the interruptions of service since then have taught a few lessons to us as well as to the cable manufacturing company, and it is these which I intend to mention in this paper.

This cable, which we will call No. 1, since we are now laying a second cable in the St. Lawrence River, is composed of four 19-strand conductors, each of an equivalent of 2-0 solid copper. Each conductor is covered with a 40% Para rubber compound to the thickness of ⅛-in., and then wrapped with one layer of 3-in. black insulated tape. The four conductors are twisted one revolution in 4 ft., about a common jute center; four No. 14 B. & S. gage, solid copper, rubber covered wires, as pressure wires, are laid in between the four heavy conductors on the periphery of the cable. The whole was then covered with heavy rubber filled tape and served with two layers of tarred jute. An armor of 30 No. 6 B. W. G. galvanized steel wires was spirally laid over the cable. The weak point was early shown to be the pressure wires. One of the pressure wires open-circuited in June, 1902, six months after the cable was put in service. In August, 1902, a second one open-circuited, and in October of the same year a breakdown in the cable occurred, which showed itself on one of the pairs of conductors—the cable being used for two-phase transmission. Upon minute examination of the break, which was much more difficult than would appear in the writing of this account, it was evident that a ground between the armor and one of the power conductors so weakened the insulation by virtue of the heating at that point of the rubber insulation, that a short circuit ensued between the two neighboring conductors. Further, it is the opinion of Mr. Henry and Mr. Reed, the general superintendent and the construction superintendent respectively of the Canadian Electric Light Co., as well as my own judgment, that the insulation between the armor and one conductor was weakened by the continuous inductive spark at the point in one of the pressure wires where it had open-circuited. The repairing of the cable at this point was effected, and the cable has been in successful operation since that time, except from a defect caused from what we term a mechanical cause or cause from the exterior of the cable, and by ice, in contradistinction to an internal electric cause.

Although the engineer of the cable manufacturing company and the writer carefully discussed the question before the cable manufacture of the insertion of pressure wires in this cable, it was not deemed bad engineering at that time to place such wires in the cable under discussion. This engineer had as much submarine cable experience as anyone in America, but he has learned something through the faults in our No. 1 cable, so that in placing the order last fall for a No. 2 cable, four flexible power conductors alone are in this No. 2 cable. We even discussed, at the time of placing the order for the No. 1 cable, the question of placing the pressure wires in the center of the cable rather than towards the periphery, but it was not at that time deemed unwise to place them in the peripheral position. But our experience shows that what we thought to be very unlikely actually did occur, and that it is a mistake in cable design to place the pressure wires on the outside of the larger conductors where such small wires would be subjected to greater mechanical movement than in the center of the cable, and that even if they are placed in the latter position, there is much danger of their causing trouble to the insulation of the larger conductors. Of course it can be theorized that had we made the No. 14 solid pressure wire of strands of wires we would not have had the breakdown, since the break that we did have possibly occurred at the point where the solid wire was jointed by an electric weld. But briefly, our experience is to never put conductors of materially different sizes within the same armored cable, and also to be very careful, in our climate, of the shore ends.

The greatest danger in future with our cables in the St. Lawrence River, and in fact any rivers of this northern climate, is from the ice conditions in the spring of the year. It is, consequently, absolutely essential to not only protect the shore ends from the action of the ice grinding

against the cable itself near what would be the surface of the river, but to protect the cable as it lays on the river bottom where the cable approaches the shore ends. This has been shown by some experience that we have had and that experience has taught us that in laying up the cable to the shore end where is, as may be expected, the greatest movement of the ice down river, we should approach the shore within several hundred feet at a point about the same distance down stream and thence make a detour of the cable towards the terminal point. The river depth at

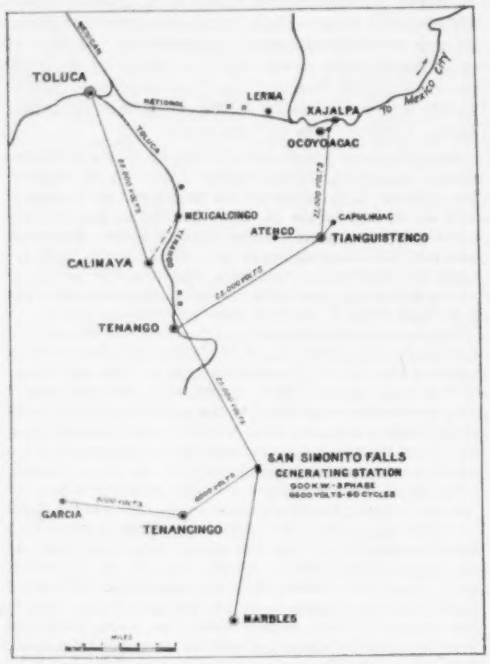

Fig. 1. Map Showing Electric Transmission Lines; Toluca Electric Light & Power Co.

such a distance from the shore is invariably greater than near the shore. As the ice catches on the bottom of the river and rotates huge cakes no damage is likely to ensue if the line of the cable be in the general direction of the movement of the ice. The overturning cakes of ice will not tend to catch in the cable as they would if the cable be laid at right angles to the direction of the flow of the river, and, where it does cross at right angles, it would lay at a point considerably below the surface of the river where the ice will not touch the cable.

The cable bells or ends which we have used have proven very satisfactory; they are merely brass tubes 5 ins. in diameter with ⅛-in. walls, brought down to a conical shape. The hole in the small end is of the size of the exterior of the cable. The tube is 2 ft. long, and is flanged or belled for an inch. With this cable end slipped over the cable, insulating compound is melted and poured in so that the bell is completely filled between its walls; the four conductors are separated as far as possible at equal distances from each other, and are jointed about 1 in. from the mouth of the bell, the insulation compound (ozokerite) being brought to the top.

I will say that in our method of laying this cable on the two occasions that we have done so, we have had the use of a special large reel capable of holding it entirely. The reel is on trunnions geared about 10 to 1 to cranks on each side of the reel, which are moved by man power. Our experience shows us that it is essential to lay the cable slowly in order to be sure and follow every indentation in the river bed, as in the drop of 170 ft., which is the depth at some points of the St. Lawrence River where our cable is situated, more time is necessary for the cable to be laid on the bottom of the river than at first thought might be considered possible. The No. 2 cable, which we are about to lay, has nearly twice as heavy armor as No. 1, as it will have No. 4 B. W. G. instead of No. 6 B. W. G. galvanized steel wire spirally served on the cable.

A MEXICAN WATER-POWER ELECTRIC PLANT.

A small but interesting water-power plant with electric distributing system has been built during the past year at San Simonito, a short distance west of the City of Mexico, and now supplies current for lighting and power to Toluca, the capital of the State of Mexico, and a number of other towns and villages within a radius of twenty miles.

The country in that neighborhood is mountainous, the difference in elevation between the highest and lowest point supplied being over 4,000 feet.

On a plain at the foot of Toluca Mountain, which is always snow covered, and some six miles above the power station, a group of springs issue from the ground at the rate of 23 cu. ft. per second and form the main source of the stream which is utilized by this company, and is dignified by the name of San Pedro River.

Five miles below the springs this stream is diverted and its waters lead by ditch, flume and penstock to an electric power station about a mile away, where a working head of about 700 ft. on the water-wheels is obtained.

While the amount of water flowing is relatively small, the springs are remarkably constant in flow, and this enabled the projectors of the plant to figure on a normal output of about 1,200 HP., but little less than that corresponding to the maximum flow.

A map of the distribution system is given in Fig. 1. As is shown there, railway connections extend only to Tenango, nearly ten miles from the power station, so that all the materials and machinery had to be hauled to the site. The topography of the country between the intake dam and the power station is exhibited on much larger scale in Fig. 2.

The intake dam which impounds the water flowing from the springs is a very small structure. Fig. 3 shows a view taken after a freshet had filled in sediment back of the dam. The dam was built of Portland cement concrete and rubble masonry laid in Portland cement mortar.

The canal from the dam to the penstock, about 4,300 ft. long, was designed to have a bottom width of 5 ft. and a depth of 3 ft. A normal stretch of canal excavated to these dimensions is illustrated by the view Fig. 4. At the point shown the material is firm enough to allow of almost vertical side slopes, but on most of the length of the canal side slopes of 1 to 1 had to be used. The location followed closely the contour lines, except where ravines were encountered. The trestle construction used to cross at such points is typically represented in Fig. 5. The sides and bottom of the flume were made of dressed lumber; the sides were drawn tight by pairs of wedges at each cross frame, and miter joints at the junction of bottom and sides served to transmit the wedging action to the bottom planks. At the ends of all sections of flume, where the latter joins the canal, rubble masonry abutments were used carried up above the top of the flume and surrounding its sides so as to seal the joint.

At the lower end of the canal is formed a small reservoir for the intake of the pipe line. It was designed for a depth of 11 ft. of water and of sufficient size to provide for a peak load 25% in excess of the normal capacity of the plant for three hours. The lower, narrow part of the reservoir is paved with rubble masonry laid dry and as close as possible, to a thickness of 15 ins. The penstock, 28 ins. in diameter,

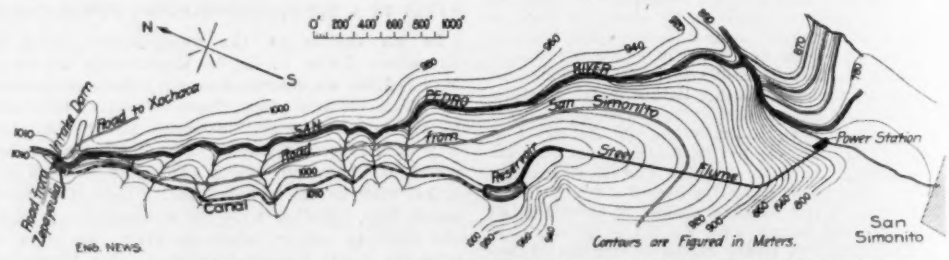

FIG. 2. TOPOGRAPHICAL MAP OF REGION TRAVERSED BY POWER CANAL AND PIPE LINE.

is made of steel varying from No. 10 sheet to 7-16-in. plate. Joints are made by steel flanges with gaskets. At some points the pipe rests on masonry pillars, but in general it is simply laid to grade on the surface of the ground or embedded to half its depth, and covered with stone and earth. It is anchored on the slopes by 1¼-in. anchor rods. At its lower end, where it runs along the wall of the power house, the pipe terminates in an enlarged section or receiver, 30 ins. in diameter and made of ½-in. steel. The tapered branch pipes to the different water-wheels connect to this receiver by forged flanges or saddles.

A plan of the power house and the arrangement of the machinery are shown in Fig. 6. The power house has walls of rubble masonry and is covered by a roof of No. 26 galvanized corrugated steel on steel trusses.

The generating machinery is in three units, each of 300 KW. rated capacity. Each unit consists of a 66-in. single-nozzle Pelton wheel running at a speed of 360 r. p. m., and connected by a leather-link flexible coupling to the generator

Fig. 3. View of Intake Dam from Upstream Excavation not Completed.

shaft, on which is a three-phase inductor generator of the S. K. C. type, wound for 6,600 volts and 60 cycles. The governing of the water-wheel is accomplished by a Pelton electric relay governor operating a deflecting hood over the nozzle. The builders guaranteed that

the water-wheels will develop an efficiency of not less than 80% with the full stream properly impinging on the buckets; the governors will control the speed of the wheels so that with an instantaneous change of load of 10% the variation in speed will not exceed 1½%, with an instantaneous change of load of 25% the variation in speed will not exceed 3½%, and with an instantaneous change of load of 50% the variation in speed will not exceed 7%.

The specifications for the wheels state on the subject of construction that

wheels and brackets are to be made of steel. They shall be extra heavy to serve as flywheels. The wheels must be mounted on hammered steel shafts, not less than 6⅛ ins. in diameter which shall be turned down at the bearings to 5½ ins.

The wheels are enclosed in cast-iron housings made in two parts connected by flanges; where the shaft passes through the housing a centrifugal disc rotating in a pocket formed in the housing is provided to prevent water traveling along the shaft. The bearings are ring-oiling, and are mounted on a common bedplate.

The alternators were specified to have the standard heating limit at full load, of 40° C. above the temperature of the air. Their guaranteed minimum efficiency on non-inductive load, 100% power factor, is 92% at full load, 89% at half load, and 82% at one-quarter full load. The regulation on non-inductive load is within 9% between no load and full load.

Two exciter units are provided, each consisting of a 30-in. Pelton wheel running at 850 r. p. m. direct-connected to a dynamo of 20 KW. capacity delivering current at 60 volts potential. The wheel and dynamo of each unit are mounted on a common bedplate. The wheels are regulated by hand.

In the transformer room are three 250-KW. transformers, oil-insulated and water-cooled. They raise the potential of the current from 6,600 to 25,000 volts for transmission over the Toluca line. The switching on the high-tension side of

these transformers is accomplished by three air-break switches mounted on a panel separate from the main switchboard. (See Fig. 6.) Three fuses, one in each of the three legs of the high-tension circuit, are also mounted on this panel. The main switchboard consists of three generator panels, each controlling the delivery circuit from one machine, one exciter panel for the two exciters, four circuit panels and one totalizing panel.

The transmission lines are of copper wire No. 0 and No. 8, on porcelain two-piece insulators carried on wooden poles. The latter average 25 ft. long, set 4 ft. in the ground, and are spaced about 125 ft. apart. Iron poles were considered, but as the relative cost of wood and iron in that section of the country was 1 to 20, it was thought cheaper to use wooden poles, replacing them every three or four years. The insulators are of the Mershon type, and are held on composite pins having a central iron bolt, a porcelain bottom section and a wooden screw section. The three wires of the circuit were arranged one on top of the pole and one at each end of a 6-ft. cross-arm fastened 5 ft. from the top of the pole. Lightning arresters are provided in the circuits at the power station and at each substation.

The substation equipment comprises lowering transformers in units of 150 KW., which reduce the potential of the current from 6,000 to 2,200 volts and at the same time convert the three-phase into two-phase current, and a switchboard consisting of receiving panel, arc panel and incandescent panel. The distributing circuits in the towns operate at 2,200 volts; they are also fitted with lightning arresters.

The concession for the water power development at San Simonito was granted early in the year of 1901 to Messrs. Alexander Potter, Consulting Engineer, of New York, and W. B. Tuteur, of Mexico City, who disposed of the concession to the Toluca Electric Light & Power Co., composed of a number of New York capitalists, with the stipulation that Messrs. Potter and Tuteur should build the complete plant in accordance with the plans prepared by Mr. Potter. Contracts for machinery were awarded in December, 1901, and the actual work of construction started a month later. The entire plant would have been completed in August, 1902, but for a peculiar and serious fire which occurred to the switchboard

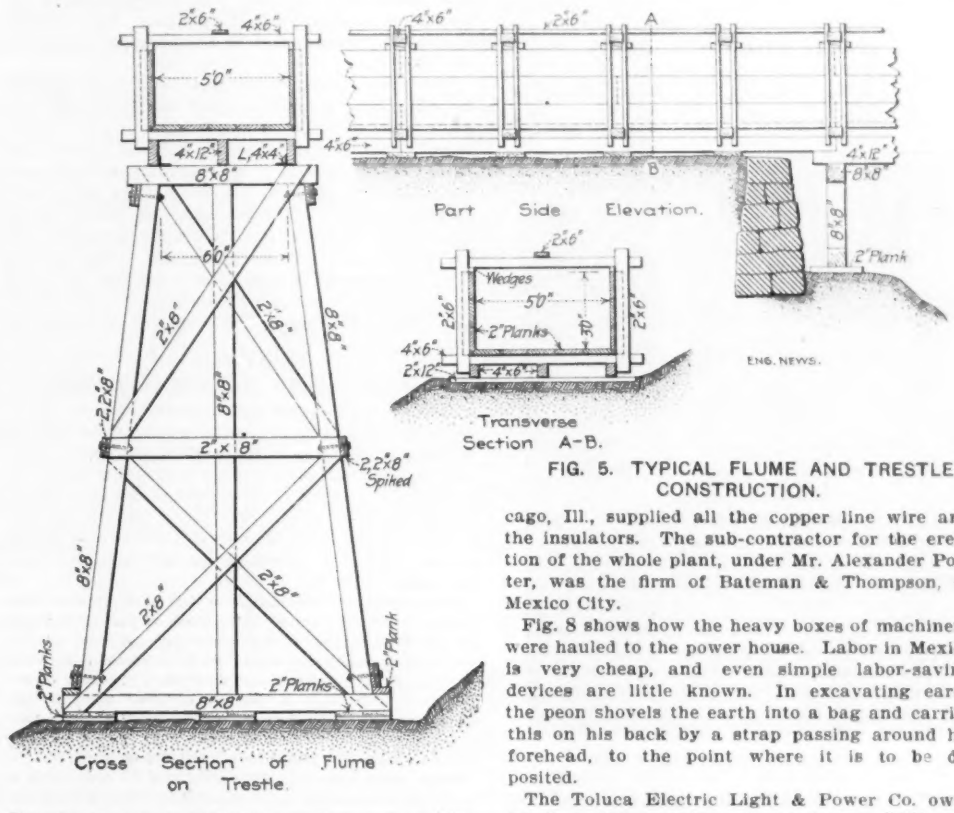

FIG. 5. TYPICAL FLUME AND TRESTLE CONSTRUCTION.

horse belonging to the sub-contractor took fright at a small fire near him, broke his hitching strap, kicked over the fire and upset some oil, which saturated his tail and took fire. The horse ran around the enclosure in which were fifty boxes of electrical apparatus, setting fire to many of them. The town authorities, all Mexicans, believed that dynamite was stored in the enclosure and would not allow any one to go near the blazing boxes until the fire burnt itself out. A delay of eight months was occasioned by this accident, combined with other causes.

latter furnishing the transformers. The Pelton Water-Wheel Co., of New York City, furnished the water-wheels, the electric governors and the steel penstock. The Western Electric Co., of Chicago, Ill., supplied all the copper line wire and the insulators. The sub-contractor for the erection of the whole plant, under Mr. Alexander Potter, was the firm of Bateman & Thompson, of Mexico City.

Fig. 8 shows how the heavy boxes of machinery were hauled to the power house. Labor in Mexico is very cheap, and even simple labor-saving devices are little known. In excavating earth the peon shovels the earth into a bag and carries this on his back by a strap passing around his forehead, to the point where it is to be deposited.

The Toluca Electric Light & Power Co. owns another fall capable of developing 8,000 HP. As soon as the present plant reaches the maximum capacity it is the intention of the company to develop this other property for transmission to Toluca, while the power of the San Simonito property will be used in developing industries in the country near the present power station. There are a number of towns within a radius reached by

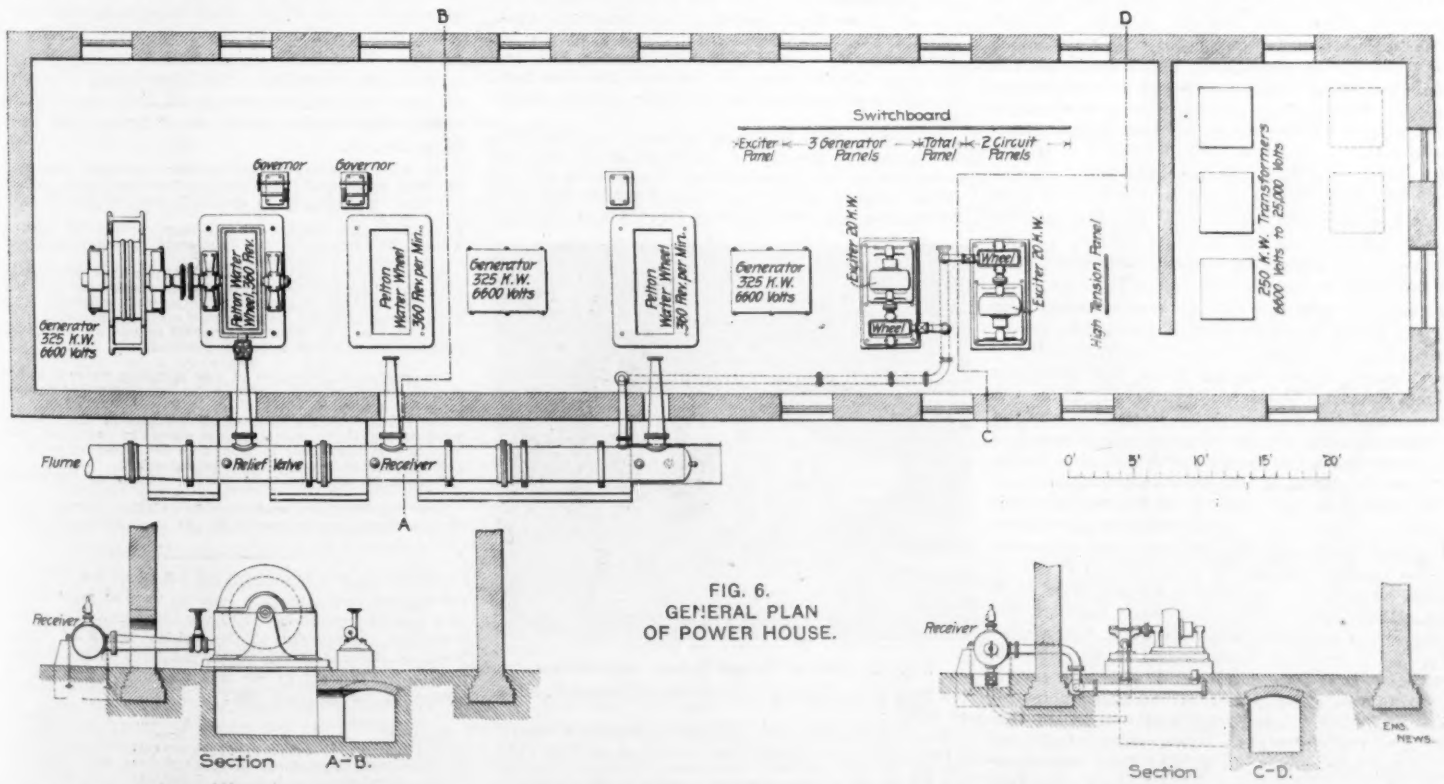

FIG. 6. GENERAL PLAN OF POWER HOUSE.

apparatus while awaiting transportation across country at the storage yards at Tenango, the terminus of the railway. This fire caused a delay in the completion of the plant until April, 1903. A

The contracts for the electrical machinery were divided between the Stanley Electric Mfg. Co. and the General Electric Co., the former furnishing the generators and switchboard apparatus, the

the company's wires where contracts for city lighting and power have been or will be secured.

We are indebted to Mr. Potter for the material from which this article was prepared.

THE CITY AND HARBOR OF DALNY, CHINA.

The Chinese Eastern Ry., which has been built by Russian capital and forms the eastern section of the Siberian Railway, will have its main terminal at the new city and harbor of Dalny, about 20 miles from Port Arthur. This port occupies territory leased to Russia by the Chinese government for 25 years, with provision for renewal. According to a report made by Mr. M. M. Langhorne, U. S. Commercial Agent at Dalny, the township

Fig. 4. View of Portion of Canal.

comprises an area of 21,000 acres, and during the current year it is proposed to purchase an additional tract of 7,000 acres on the northwest. The lands forming the township were purchased in 1899 by the Chinese Eastern Ry. from the local inhabitants, at a price fixed by a committee of appraisers. It is divided into three parts: the Administration City, the European and Commercial City, and the Chinese City. It is supplied with water and electric lights throughout, and has an adequate police force and fire brigade. The administration is vested in a town council, of which the Governor is chairman. The town council is composed of six regular members and three substitutes. Three of the members must be Russian citizens, and one appointed by the Chinese Eastern Ry. Co.

The climate of Dalny is agreeable, healthful and dry. The temperature in winter for the last four years has not been below — 3° F. During very severe winters the bay becomes frozen, but ice breakers are to keep the channel and harbor open for navigation.

Among the principal industries now established are the small dry dock and harbor repair shops, electric light and power station, iron foundry, city work shops, steam drying mills and furniture shops, concrete block factory, brick yards, tile factory, and gas works. In the construction of the city thousands of Chinese laborers are engaged in the excavations, the making of streets and roads, and the completion of the work on the harbor.

The harbor is the scene of the greatest activity at present. The small harbor has been dredged to a depth of 18 ft., and the pier for coast steamers (which has been in use for over a year) is nearly completed and has a railway at its end. The work on the large dry dock is progressing rapidly; the cofferdam is built and the excavation well under way. This dry dock is to be 630 ft. long, 88 ft. wide, and 28 ft. in depth, and will cost about $927,000. The eastern side of the large pier for ocean steamers is completed and in use, on the west side the walls are nearing completion, and one of the iron wharves for light-draft vessels is built. Three railway tracks connecting with the main line and two storage warehouses, with a floor area of 19,600 sq. ft. each, are completed. This pier is 1,925 ft. long and 350 ft. wide, and has a depth of water of 18 to 28 ft. When completed it will contain seven railway tracks and nine large warehouses. The foundation is laid with 50-ton concrete blocks, and the walls finished with dressed granite. For the outside pier the foundation only is laid. The wharf between the two piers is completed and in use. The foundation of the breakwater is finished for a distance of 2,800 ft.

The first passenger express train from St. Petersburg and Moscow arrived at Dalny Feb. 21, 1903, and now a semi-weekly service is established. The trip to Moscow, a distance of 5,375 miles, with a change of cars at Manchuria station and Baikal, is made in 13½ days. The fare to St. Petersburg is $137.96 first class, and $91.97 second class. The Chinese Eastern Ry. steamers number 19, with a net tonnage of 20,205. They are intended for coast service, but there are two new express steamers, the "Manchuria" and "Mongolia," making trips to Shanghai and Nagasaki in 36 hours.

ASPHALT PAVING COST AND GUARANTEES.

The guarantees for maintenance and repair of asphalt pavements are a frequent source of confusion and dispute in contract work, and in our issue of July 30 we gave an abstract from a report on the subject of repairing asphalt pavements in New York. The July bulletin of the League of American Municipalities contains a note on this subject from which we take the following extracts:

From the best information at hand, it appears that asphalt and brick lead all other kinds of paving in popularity. Wood is now almost out of use, and stone is used only where exceedingly heavy traffic demands a material of extraordinary strength and durability. Because of recent general increase in the cost of labor, the price for brick pavement has increased, while asphalt shows a material reduction in cost, presumably due largely to competition afforded by the more general use of brick.

While there should be some hesitancy in demanding a low-priced pavement because of a possibility that the quality of the material and workmanship may be sacrificed in securing such result, yet one cannot but feel, after noting the varying prices, that some municipalities are paying too dear for their pavements.

In 1899, Meriden, Conn., paid for asphalt paving under a ten-year guarantee, $2.96 per yd. In the same year Hartford, Conn., paid $2.56 per yd. under a five-year guarantee, while Geneva, N. Y., under a 15-year guarantee, paid but $1.75, and Louisville, Ky., $1.59 under a five-year guarantee.

In 1900, New Haven paid $2.81, and Somerville, Mass., $2.75 per yd., while Owensboro, Ky., paid $1.80. In 1902 Chattanooga, Tenn., paid $2.70, while Houston, Tex., paid but $1.85. All this work was done with the same brand of asphalt and under almost the same general requirements.

The specifications for asphalt pavement in Washington, D. C., call the attention of the bidder to the fact that under the current Congressional appropriation bill, no contract will be entered into at a cost greater than $1.80 per sq. yd. The famous asphalt pavements of Washington have been known to cost on some contracts as low as $1.56.

Fig. 7. View of Power House from Below.

Mr. B. T. Fendall, City Engineer of Baltimore, says:

The cost of sheet asphalt has varied with us from $1.52 per yd. to $3.50 per yd. The price of $1.52 per yd. was the bid of the Alcatraz Company, prior to its absorption by the Trust. The pavement laid by this company is one of the best we have. It was laid in 1898; it is under heavy traffic, and is to all appearances as good to-day as when first laid. It is guaranteed for five years, and so far the contractor has not been called upon to make repairs, none being required.

NEW YORK RULES IN AID OF MOSQUITO EXTERMINATION AND THE PREVENTION OF MALARIAL FEVER.

Much has been written in recent years regarding mosquito extermination and no little work designed to lessen mosquitos has been done along the North Atlantic coast. The activity thus far shown has been due to local boards of health, on the one hand, and on the other, to owners of large private estates, or associations of suburban residents. The first measure to attract attention was spraying mosquito-breeding bodies of water with crude petroleum. The elimination of many of the breeding places by drainage or filling, it was soon apparent, being a much more reasonable and the only permanent remedy one or the other of these plans has been adopted, when feasible, wherever the anti-mosquito campaign has been carried on most intelligently. But oiling, draining and filling, combined in accordance with local conditions, are not sufficient to eliminate the mosquito when receptacles for stagnant water abound in the immediate vicinity of houses. To guard against this very troublesome class of breeding places the Department of Health of New York city adopted, same time ago, the following regulations, which are in force from April 15 to Oct. 15.

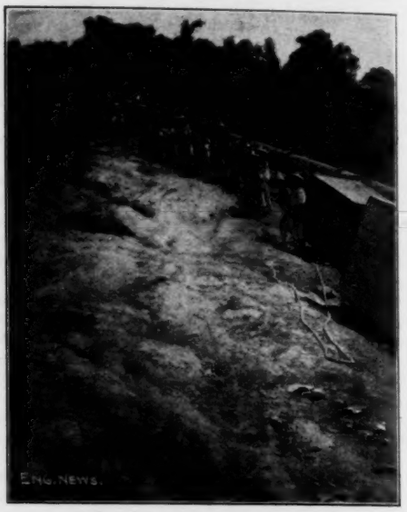

Fig. 8. Hauling Boxes of Machinery Along Pipe Line.

(1) No rain-water barrel, cistern, or other receptacle for rain water shall be maintained without being tightly screened by netting, or so absolutely covered that no mosquito can enter.

(2) No cans, pails, or anything capable of holding water, shall be thrown out or allowed to remain unburied on or about the premises.

(3) Every uncovered cesspool or tank shall be kept in such condition that oil may be freely distributed and flow over the surface of the water. Covered cesspools must have covers perfectly tight and all openings screened.

(4) No waste or other water shall be thrown out or allowed to stand on or near the premises.

Information is requested of any standing water that the premises may be inspected and the legal remedies against same be applied.

The prompt co-operation of all persons in the enforcement of the above regulations is earnestly requested, and they are assured that in this way the breeding of mosquitoes on their premises will be prevented.

Mosquitoes are the only proven means of conveying malaria.

Any inquiries, or complaints in relation to the above matter, should be forwarded to the local sanitary officer. —Ed.)

THE WORLD'S PRODUCTION OF IRON AND STEEL

for the last twelve years is reported upon at great length in a volume recently issued by the Commercial Labor and Statistical Department of the British Board of Trade. From an abstract of this report published in the London "Engineer" of July 31 we take the following figures of production for the year 1901:

Country.	Pig Iron, tons.	Steel, tons.
United States	15,878,000	13,474,000
Germany and Luxemburg	7,867,000	6,394,000
United Kingdom	7,929,000	4,904,000
Russia	2,821,000	.....
France	2,389,000	1,425,000
Austria-Hungary	1,482,000	.....
Belgium	764,000	633,000
Sweden	528,000	268,000
Spain	.....	121,000